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1892–1921

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THE MINERAL INDUSTRY

ITS

STATISTICS, TECHNOLOGY AND TRADE

DURING

1921

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THE STATE GEOLOGICAL SURVEYS

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State.	Name and Address.	State.	Name and Address.
ALABAMA.....	Eugene A. Smith, University.	NEW MEXICO..	R. W. Ellis, Albuquerque.
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		OHIO.....	J. A. Bownocker, Columbus.
		OKLAHOMA.....	C. W. Shannon, Norman.
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INDIANA.....	W. N. Logan, Indianapolis.	S. CAROLINA...	Stephen Taber, Columbia.
IOWA.....	George F. Kay, Director, Iowa City.	S. DAKOTA.....	Freeman Ward, Vermilion.
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NEBRASKA.....	E. H. Barbour, Lincoln.	WYOMING.....	G. B. Morgan, Cheyenne.
NEW JERSEY...	H. B. Kümmel, Trenton.		

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ALABAMA.....	C. H. Nesbitt, Chief Mine Inspector, Birmingham.
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ARIZONA.....	J. F. White, Chief Mine Inspector, Phoenix; G. Montague Butler, Director, State Bureau of Mines, Tucson.
ARKANSAS.....	James G. Ferguson, Commissioner, Bureau of Mines, Manufactures and Agriculture, Little Rock; Jess Redyard, State Mine Inspector, Fort Smith.
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VALUE OF FOREIGN COINS

ESTIMATE BY DIRECTOR OF THE MINT, JAN. 1, 1922

Country.	Standard.	Monetary Unit.	Value in Terms of U.S. Gold Dollar.	Exchange Value. (d)	Coins and Remarks.
Argentine Republic.	Gold..	Peso.....	$0.9648	Gold, $0.731	Gold: argentine ($4.824) and ½ argentine. Silver: peso and divisions. Currency: Depreciated paper, convertible at 44 per cent. of face value; now inconvertible.
Austria-Hungary..	Gold..	Krone.....	.2026		Gold: 10 and 20 crowns. Silver, 1 and 5 crowns.
Belgium.....	Gold..	Franc.....	.1930	.074	Gold: 10 and 20 francs. Silver: 5 francs.
Bolivia.....	Gold..	Boliviano.....	.3893		Silver: boliviano and divisions, 12½ bolivianos equal 1 pound sterling.
Brasil.....	Gold..	Milreis.....	.5462	.131	Gold: 5, 10 and 20 milreis. Silver: ½, 1 and 2 milreis. Currency: Government paper.
British Colonies in Australasia and Africa.....	Gold..	Pound sterling.....	4.8665		
Canada.....	Gold..	Dollar.....	1.0000	.896	
Central America: Costa Rica.....	Gold..	Colon.....	.4653		Gold: 2, 5, 10 and 20 colons ($9.307). Silver: 5, 10, 25 and 50 centimos.
British Honduras.....	Gold..	Dollar.....	1.0000		
Nicaragua.....	Gold..	Cordoba.....	1.0000		
Guatemala... / Honduras....	Silver..	Peso.....	.9271		Guatemala: Currency, inconvertible paper. Honduras: Currency, bank notes.
Salvador.....	Gold..	Colon.....	.5000		Currency, convertible into silver on demand.
Chile.....	Gold..	Peso.....	.3650	.120	Gold: escudo ($1.825), doubloon ($3.650), and condor ($7.300). Silver: peso and divisions. Currency: Inconvertible paper.
China.....	Silver	Tael.. Amoy.....	.8156		The tael is a unit of weight; not a coin. The customs unit is the Haikwan tael. The values of other taels are based on their relation to the value of the Haikwan tael. The Yuan silver dollar of 100 cents is the monetary unit of the Chinese Republic; it is equivalent to .644 + of the Haikwan tael.
		Canton.....	.8131		
		Cheefoo.....	.7801		
		Chin Kiang..	.7967		
		Fuchau.. ...	.7544		
		Haikwan (customs)	.8299		
		Hankow.....	.7631		
		Kiaochow...	.7903		
		Nankin.....	.8071		
		Niuchwang..	.7648		
		Ningpo.....	.7841		
		Peking.....	.7951		
		Shanghai....	.7450		
		Swatow.....	.7534		
		Takau.....	.8207		
		Tientsin.....	.7903		
		Dollar Yuan.....	.5344		
		Dollar Hongkong...	.5364		
		Dollar British.....	.5364		
		Mexican.....	.5404		
Colombia.....	Gold..	Dollar.....	.9733		Gold: condor ($9.647) and double condor. Silver: peso
Cuba.....	Gold..	Peso.....	1.0000		Currency, Government paper and gold
Denmark.....	Gold..	Krone.....	.2680	.178	Gold: 10 and 20 crowns.
Ecuador.....	Gold..	Sucre.....	.4867		Gold: 10 sucres ($4.8665). Silver: sucre and divisions.
Egypt.....	Gold..	Pound (100 piasters).	4.9431		Gold: pound (100 piasters), 5, 10, 20 and 50 piasters. Silver: 1, 2, 5, 10 and 20 piasters. The actual standard is the British pound sterling, which is legal tender for 97½ piasters.

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Country.	Standard.	Monetary Unit.	Value in Terms of U.S. Gold Dollar.	Exchange Value. (*d*)	Coins and Remarks.
Finland	Gold	Markka	.1930		Gold: 20 marks ($3.8), 5910 marks ($1.93).
France	Gold and Silver	Franc	.1930	.075	Gold: 5, 10, 20, 50 and 100 francs. Silver 5 francs. Member of Latin Union; gold is the actual standard.
Germany	Gold	Mark	.2382	.011	Gold: 5, 10 and 20 marks.
Great Britain	Gold	Pound sterling	4.8665	3.85	Gold: sovereign (pound sterling).
Greece	Gold and Silver	Drachma	.1930		Gold: 5, 10, 20, 50 and 100 drachmas. Silver: 5 drachmas. Member of Latin Union; gold is the actual standard.
Haiti	Gold	Gourde	.2500		Gold: 1, 2, 5 and 10 gourdes. Silver: gourde and divisions. Currency: Inconvertible paper.
India (British)	Gold	Rupee(*a*)	.3244	.263	Gold: sovereign (pound sterling). Silver: rupee (15 rupees = 1 pound sterling).
Indo-China	Silver	Piaster	.5942		
Italy	Gold and Silver	Lira	.1930	.043	Gold: 5, 10, 20, 50 and 100 lire. Silver: 5 lire. Member of Latin Union; gold is the actual standard.
Japan	Gold	Yen	.4985	.483	Gold: 5, 10 and 20 yen. Silver: 10, 20 and 50 sen.
Liberia	Gold	Dollar	1.0000		Currency: Depreciated silver token coins. Customs duties are collected in gold.
Mexico	Gold	Peso(*b*)	.4985		Gold: 5 and 10 pesos. Silver: dollar (or peso) and divisions. (*c*) Exchange value, silver peso, $1.015.
Netherlands	Gold	Guilder (Florin)	.4020	.337	Gold; 10 florins. Silver: 2½, 1 florin, and divisions.
Newfoundland	Gold	Dollar	1.0000		Gold: 2 dollars ($2.027).
Norway	Gold	Krone	.2680	.149	Gold: 10 and 20 crowns.
Panama	Gold	Balboa	1.0000		Gold: 1, 2½, 5, 10 and 20 balboas. Silver: peso and divisions.
Paraguay	Gold	Peso (Argentine)	.9648		Currency: Depreciated paper.
Persia	Gold	Achrefi	.0959		Gold: ½, 1, and 2 tomans ($3.409). Silver: 14, ½, 1, 2 and 5 krans.
	Silver	Kran	.1013		
Peru	Gold	Libra	4.8665		Gold: ½ and 1 libra. Silver: sol and divisions.
Philippine Islands	Gold	Peso	.5000		Silver peso: 10, 20 and 50 centavos.
Portugal	Gold	Escudo	1.0805		Gold: 1, 2, 5 and 10 milreis. Currency: Inconvertible paper.
Roumania	Gold	Leu	.1930		
Russia	Gold	Ruble	.5146		Gold: 5, 7½, 10 and 15 rubles. Silver: 5, 10, 15, 20, 25, 50 and 100 copecks.
Santo Domingo	Gold	Dollar	1.0000		
Servia	Gold	Dinar	.1930		
Siam	Gold	Tical	.3709		
Spain	Gold and Silver	Peseta	.1930	.133	Gold: 25 pesetas. Silver: 5 pesetas. Valuation is for the gold peseta; currency is notes of the bank of Spain.
Straits Settlements	Gold	Dollar	.5678		Gold: sovereign (pound sterling). Silver: dollar and divisions.
Sweden	Gold	Krona	.2680	.226	Gold: 10 and 20 crowns.
Switzerland	Gold	Franc	.1930	.174	Gold: 5, 10, 20, 50 and 100 francs. Silver: 5 francs. Member of Latin Union; gold is the actual standard.
Turkey	Gold	Piaster	.0440		Gold: 25, 50, 100, 250 and 500 piasters. 100 piasters equal to the Turkish £.
Uruguay	Gold	Peso	1.0342		Gold: peso. Silver: peso and divisions.
Venezuela	Gold	Bolivar	.1930		Gold: 5, 10, 20, 50 and 100 bolivars. 5 bolivars.

(*a*) The sovereign is the standard coin of India, but the rupee ($0.3244½) is the current coin, valued at 15 to the sovereign. (*b*) Seventy-five centigrams fine gold. (*c*) Value in Mexico, $0.4985. (*d*) Average during 1921.

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INTRODUCTION

THE MINERAL INDUSTRY aims to present annually a review of the progress in the mining and metallurgical industries during the last calendar year. The work is a compilation of data, information, and discussion from many sources and from all parts of the world. This it is aimed to present in a permanent, readily usable form as soon as practicable after the close of the year under review. Each mineral or metal of commercial importance is taken up in a separate chapter, the various sections appearing in the volume in alphabetical order. There is included also a special review of ore dressing and coal preparation, and a section of detailed tables of the mineral and metallurgical production, imports and exports, of the principal countries of the world.

In order that the information and discussion given may be as far as possible authoritative, the services of a specialist have been enlisted in the preparation of all save a few of the minor chapters. In many cases these contributors have given liberally of their time in correspondence and in writing, so that their chapters represent much more than compilation. The work of these specialists in the different fields insures that statistics, extracts from periodicals, and abstracts of reports are given in the light of authoritative judgment.

The volume is international in scope. It is the intention to review developments and publish data from all countries, and to make the book of value to users the world over as well as in the United States. It is only natural, however, that the domestic side is emphasized. The activities of the United States Geological Survey, the United States Bureau of Mines, and the Bureau of Foreign and Domestic Commerce are so extended and so well carried out that information on the industry in this country is far more detailed and easier of collection than that in other countries. Most of the contributors are located in this country, and the availability of the American periodicals adds its share. The reports of many other countries, too, are much delayed; but some of them deserve great credit for the issuance of valuable reports in the face of present difficulties.

We owe this year special acknowledgment to the three United States Government Bureaus mentioned above. Other sources of material used in the make-up of the volume are the reports of foreign governments, the columns of the United States and foreign technical press, and the personal knowledge and correspondence of the individual contributors.

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Among the periodicals of special value have been the following: *Engineering and Mining Journal, Mining and Scientific Press* (now consolidated as *Engineering and Mining Journal-Press*), *Transactions of the American Institute of Mining and Metallurgical Engineers, Chemical and Metallurgical Engineering, The Coal Age, The Iron Age, American Fertilizer, Mining Journal, Mining Magazine, Canadian Mining Journal, Canadian Chemistry and Metallurgy, Queensland Government Mining Journal, South African Mining and Engineering Journal, L'Echo des Mines et de la Metallurgie, Annales des Mines* (France), and *Annales des Mines de Belgique.* An effort is made to credit to the source from which it is obtained all material taken from these or other publications; any failure in this respect is due to oversight, and not to intentional appropriation.

A number of minerals of lesser importance from a technical standpoint have not been covered in this work. This applies in particular to those connected with the pottery and building trades, whose raw materials are so widely distributed that a general report would require space out of all proportion to its value in a review of this kind. On the other hand, some industries relating to manufactured material are included, when the product is directly dependent on the production of raw minerals, or where it is being substituted for them, as in the case of cement and coke.

Since at best it requires some months after the close of the year for the collection of statistics, and often approximate figures are obtainable long before final completion, it is in many cases necessary and desirable to use such preliminary figures and estimates, with indication of the fact that the figures are not final. These are revised in later issues by substitution of final and official data, and it is therefore of importance in using MINERAL INDUSTRY always to refer to the latest volume, even for the figures for previous years.

Space limitations are of course a considerable handicap in a volume of this kind. It is hoped that where subjects have not been treated in as great detail as might be desired, appended references may be found of value in pursuing a fuller investigation of published information.

G. A. ROUSH
ALLISON BUTTS.

BETHLEHEM, PA.,
July 15, 1922.

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ABRASIVES

By J. Volney Lewis

The abrasive industry in common with most other branches of the mineral industry was in a state of marked depression during 1921. Activity was at a low ebb in both the natural and the artificial sides of the abrasive business, production in general amounting to only about half that of the previous year. An exception is noted in the case of pulpstones, which showed an increased production for the reason noted below.

Natural Abrasives

No corundum has been produced in either the United States or Canada since the war period. Imports were nearly cut off during the war, but were resumed on a larger scale than ever before during the period immediately following. In 1921 they declined 50 per cent. below those of 1920, but were still very large as compared with pre-war figures.

The situation in regard to emery is similar, except that imports of emery since the war have been much smaller than before it, due to the competition from artificial abrasives. There has been some output from the mines in New York and Virginia, but in 1921 this fell to very small figures. The industrial boom after the Armistice caused some increase in emery imports, but a decline followed in 1920. There was some further decline in 1921, although the amount held up remarkably well under the conditions. It is stated that there has been some difficulty with regard both to the regularity and the quality of both Grecian and Turkish emery, but that this condition has now been overcome, so that shipments of pre-war quality in sufficient amount to supply the demand can readily be obtained.

In 1921 natural abrasives were produced in 26 states, which are listed below:[1]

Alabama.....Millstones.
Arkansas.....Oilstones.
California.....Diatomaceous (infusorial) earth, grinding-pebbles, and pumice.
Connecticut.....Diatomaceous (infusorial) earth.
Illinois.....Tripoli.
Indiana.....Oilstones and rubbing-stones.
Kansas.....Pumice.
Kentucky.....Hones.
Maryland.....Diatomaceous earth.

[1] *Min. Res. of the U. S.*, 1921, U. S. Geol. Surv.

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Michigan.....Grindstones.
Minnesota.....Grinding-pebbles and tube-mill lining.
Missouri.....Tripoli.
Nebraska.....Pumice.
Nevada.....Diatomaceous (infusorial) earth and grinding-pebbles.
New Hampshire.....Garnet, millstones, and scythestones.
New York.....Diatomaceous (infusorial) earth, emery, garnet, and millstones
North Carolina.....Millstones.
Ohio.....Grindstones, pulpstones, oilstones, and scythestones.
Oklahoma.....Tripoli.
Oregon.....Diatomaceous (infusorial) earth.
Pennsylvania.....Rottenstone.
Utah.....Diatomaceous (infusorial) earth.
Vermont.....Scythestones.
Virginia.....Emery and millstones.
Washington.....Diatomaceous (infusorial) earth.
West Virginia.....Grindstones and pulpstones.

Artificial Abrasives

All of the concerns manufacturing artificial abrasives found it necessary greatly to curtail operations during 1921. Most of the electric-furnace plants were shut down during the year and have not yet resumed production. There is, however, a better outlook in the market than there was all during the past year.

The artificial abrasives produced in the United States and Canada[1] are of three kinds—(1) metallic abrasives, manufactured by the Pittsburgh Crushed Steel Co., Pittsburgh, Pa., and including "diamond crushed steel" (crushed crucible steel), "angular grit" (crushed chilled iron), and "crushed cast iron;" (2) silicon carbides, including carborundum, manufactured by the Carborundum Co., at Niagara Falls, N. Y.; crystolon, manufactured by the Norton Co., at Chippewa, Ont., and carbolon, manufactured by the Exolon Co., at Thorold, Ont., and Blasdell, N. Y.; (3) aluminium oxides, including alundum, manufactured by the Norton Co., at Niagara Falls, N. Y., and Chippewa, Ont.; aloxite, manufactured by the Carborundum Co., at Niagara Falls, N. Y., Niagara Falls, Ont., and Shawinigan, Que.; exolon, manufactured by the Exolon Co., at Blasdell, N. Y., and Thorold, Ont.; lionite, manufactured by the General Abrasives Co., Inc., at Niagara Falls, N. Y.; coralox, manufactured by the D. A. Brebner Co., Ltd., at Hamilton, Ont.; and natite, manufactured by the National Abrasive Co., at Hamilton, Ont.

So far as known to the Geological Survey, these are the only artificial abrasives manufactured in North America. Artificial abrasives sold under other names are merely the above-named products marketed under special trade names or are imported products.

[1] U. S. Geol. Surv.

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Grinding-wheels

Grinding-wheels have a very extended use in industry, but the automotive industry is now responsible for a larger percentage of the consumption than any other branch. The demand for the wheels from this source suffered in two respects during 1921, partly from the depression in the industry, and partly because automobile manufacturers were still heavily stocked with abrasive materials obtained during the unusually prosperous period following the Armistice. Accordingly not many new purchases were required during 1921, but there was a very great reduction in this stock of carried-over material, as was evidenced by decidedly better conditions as regards demand for abrasives in the spring of 1922.

Grinding-wheels employ both natural and artificial abrasives. It is claimed that for some classes of work wheels of the natural Grecian Naxos emery are to be preferred, while for other work wheels made of equal parts of natural emery and artificial abrasives give excellent results. As noted in the report last year, however, the greater uniformity and reliability of the artificial product has caused it practically to supplant emery for wheels used in precision grinding for the great majority of purposes.

The prices of grinding wheels were reduced in the latter part of 1920 and again in 1921. The reduction has not been commensurate with that in most other lines, however, for the reason that prices of abrasive materials were not previously advanced to any such degree as most other commodities.

Grindstones and Pulpstones Produced in 1921

The output of grindstones and pulpstones in the United States in 1921 amounted to 26,340 tons, valued at $1,227,322, according to figures reported by the producers to the U. S. Geological Survey. This was a decrease from the output in 1920 of over 50 per cent. in quantity and of 28 per cent. in value.

The grindstones produced amounted to 16,310 short tons, valued at $477,259, a decrease of 63 per cent. in quantity and 61 per cent. in value.

The pulpstones produced amounted to 10,030 short tons (2940 pieces) valued at $750,063, an increase of 16 per cent. in quantity and 63 per cent. in value. The demand at paper mills, which were very active late in 1920 and early in 1921 and which during and after the war could not renew their supply of English stone, increased the market for domestic pulpstones. If the depression that has followed this activity continues there will probably be a considerable decrease in the output of pulpstones in 1922.

The imports of grindstones and pulpstones were valued at $81,880 as

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against $77,046 in 1920. The exports of grindstones were valued at $281,976 as against $424,322 in 1920.

Pumice

The chief source of the world's supply of pumice is the island of Lipari, province of Messina, off the north coast of Sicily, and about 40 miles from the mainland of Italy. About twenty firms on the island are engaged in the export trade and competition is active. Mining methods are crude, and devices for grinding and preparation of the material still more so. Most of the material is shipped in chip or lump form for grinding in the countries which import it.

The output of pumice in Italy in 1921 was 10,900 metric tons, compared with 25,200 tons in 1920 and 13,200 tons in 1919. In 1920 the output of ground pumice was 9325 metric tons, the figure for 1921 being not yet available.

Tripolite

Tripolite is a silicious material closely related to quartz which is used very extensively as an abrasive product. Its production was carried on by one firm in Canada during 1921, operating a deposit in Nova Scotia. Some 300 tons was mined and milled and a total of 341 tons valued at $11,268 was shipped during the year.[1]

Market[2]

Pumice.—Competition among American grinders of Italian pumice was unusually keen during 1921, being even reported to have passed the limits necessary to assure an equitable distribution of the business.

The sales price on pumice stone during the year averaged around 3 cts. per lb. at the factory, in quantity lots, for the best grade of American-ground Italian. Domestic sold at a range as low as $15 per ton, depending upon grading. Both grades were in demand. Of the two, the Italian is used for finishing and the domestic for cleaning and scouring powders. The Italian is ground at Brooklyn and elsewhere and distributed direct to jobbers as well as to large consumers. The domestic is also sifted and purified and distributed in the same way. Practically no exports were made in 1921. All the material is prepared by refinement and separation of the various grades of coarseness. The volume of business in 1921 was probably about one-third of that in 1920, although 1920 was abnormal. No contracts are being placed for 1922 business.

A clash of interests has arisen between the dealers in Italian and domestic pumice. California, Nebraska, and Kansas owners of pumice deposits are asking the Government to increase the duty to 1 ct. per lb. However, the importers claim that the physical difference between the

[1] Prelim. Rept. Min. Prod. of Canada, 1921, Dominion Bur. of Statistics.
[2] *Eng. Min. Jour.*, Feb. 11, 1922.

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domestic and the Italian is such that the domestic product can never be substituted for Italian pumice, and that an increased duty will only penalize all the users of pumice to that extent. They claim that no pumice stone found in this country compares with the Italian.

Emery.—The large number of grades of emery marketed are sold mostly direct to consumers by the American millers of crude lump emery. The Turkish and Greek products declined from a general average of about 7½ cts. per lb. down to 6 cts. throughout the year and the American emery from around 5 cts. per lb. down to about 3½ cts. The finer grades have been mostly in demand. There have been comparatively few importations of the ground emery, the Turkish and Greek coming in the lump form. There have been few exports. Sales over 1921 declined approximately 50 per cent. as compared with those of the preceding year, and production has been cut down in about the same proportion. A distinct improvement was noted, however, in the last quarter of the year, although no contracts are reported as being made ahead by buyers. The general condition is quiet, with a decidedly optimistic tone concerning the outlook.

STATISTICS

HIGH-GRADE ABRASIVES IN THE UNITED STATES (*a*)
(In short tons)

	Domestic.		Imported Emery and Corundum.	Total Mineral Abrasive.		Artificial Abrasives.			
						Domestic. (*b*)		Imported Value.	Total Value.
	Garnet.	Emery and Corundum.		Tons.	Value.	Tons.	Value.		
1914	4,231	485	14,457	18,968	$508,800	15,830	$1,685,410	$233,799	$1,919,209
1915	4,301	3,895	10,116	17,480	435,732	18,842	2,248,778	255,474	2,504,252
1916	6,171	15,282	9,252	30,705	533,976	38,806	2,935,909	940,219	3,876,128
1917	4,995	17,135	2,250	24,380	649,979	57,911	8,137,242	1,758,910	9,896,152
1918	4,600	10,422	9,548	24,666	975,206	50,913	7,682,597	1,962,280	.....
1919	4,944	2,601	13,043	20,588	887,498	50,518	7,465,849	1,241,059	.....
1920	5,476	2,327	10,111	17,914	1,061,915	42,437	7,492,164	1,751,092	.....
1921	3,048	805	7,662	11,015	627,639	13,199	1,996,147	519,509	.....

(*a*) U. S. Geol. Surv. (*b*) Includes Canadian production after 1917.

EMERY PRODUCED IN THE UNITED STATES, 1913–1921
(U. S. Geological Survey)

Year.	Short Tons.	Value.	Average per Ton. (*d*)
1914	485(*a*)	$ 2,425(*a*)	$ 5.00(*a*)
1915	3,063(*a*)	31,131	10.17(*a*)
1916	15,282	123,901	8.11
1917	17,135(*b*)	241,050(*b*)	14.07(*b*)
1918	10,422(*c*)	112,878(*d*)	10.83
1919	2,601	23,203	8.92
1920	2,327	21,685	9.32
1921	805	2,250	7.38

(*a*) Estimated. (*b*) Includes 820 short tons of corundum from North Carolina, valued at $67,461 or $82.28 per ton; the emery alone averaged $10.64 per ton. (*c*) Includes North Carolina corundum. (*d*) Value of marketed material.

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IMPORTS OF EMERY INTO THE UNITED STATES, 1913–1921
Years ending June 30, (Bureau of Foreign and Domestic Commerce)

	Ore.		Grains.		Manufactures Value.	Total Value.
	Long Tons.	Value.	Pounds.	Value.		
1913	18,964	$328,211	922,660	$37,307	$15,067	$380,585
1914	14,197	275,973	844,157	33,874	20,874	330,721
1915	7,194	152,088	629,581	25,011	.....	177,099
1916	10,255	194,954	461,461	18,712	35,142	248,808
1917	2,000	14,282	136,969	7,889	33,535	55,706
1918	3,609	88,875	482,289	32,371	44,390	165,636
1919(a)	8,302	235,596	392,789	22,432	41,039	299,067
1920(a)	5,398	222,321	754,880	22,445	11,382	256,148
1921(a)	5,181	179,957	546,560	7,973	28,752	216,682

(a) For the calendar year.

IMPORTS OF CORUNDUM INTO THE UNITED STATES, 1913–1921
Years ending June 30, (Bureau of Foreign and Domestic Commerce)

	Ore.		Grains.		Total Value.
	Long Tons.	Value.	Pounds.	Value.	
1913	541	$78,401	1,937,803	$87,187	$165,588
1914	294	39,772	1,114,051	61,026	100,798
1915	183	23,701	831,350	39,914	63,615
1916	17	633	657,826	29,471	30,104
1917	283	27,503	2,310,594	128,941	156,444
1918	1,182	119,522	3,421,454	189,345	308,867
1919(a)	3,168(a)	296,136	154,560	9,696	305,832
1920(a)	2,828	297,518	1,223,040	63,511	361,029
1921(a)	988	101,974	1,137,920	74,798	176,772

(a) For the calendar year.

COMPARATIVE VALUES OF IMPORTS, 1913–1921
Years ending June 30 (Bureau of Foreign and Domestic Commerce)

	Corundum.	Emery.	Combined Value.	Artificial Abrasives.
1913	$165,588	$380,585	$546,174	$190,290
1914	100,798	330,721	431,519	233,799
1915	63,615	177,099	240,714	255,474
1916	30,104	248,808	278,912	547,948
1917	156,444	55,706	212,150	1,370,063
1918	308,867	165,636	474,503	1,856,734
1919(a)	305,832	299,067	604,899	1,241,059
1920(a)	361,029	256,148	617,277	1,751,092
1921(a)	176,772	216,682	393,454	519,509

(a) For the calendar year.

ABRASIVES EXPORTED FROM THE UNITED STATES (a)

	1917.	1918.	1919.	1920.	1921.
Wheels, emery and other.....	$4,881,600	$3,862,531	$3,032,067	$2,791,128	$1,318,804
All others.....	1,941,512	1,982,822	2,809,231	3,810,171	1,719,810
Totals.....	$6,823,112	$5,845,353	$5,841,298	$6,601,299	$3,038,614

(a) Bureau of Foreign and Domestic Commerce.

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GARNET

BY D. H. NEWLAND

The production of abrasive garnet last year was considerably smaller than in 1920, when the marketed output was reported as 5476 tons valued at $434,425. In 1921 it was 3048 tons valued at $260,687. A normal market requires about 6000 tons, domestic and foreign garnet. Of that amount the American mines supply around 5000 tons on an average, and the remainder is imported by abrasive manufacturers from England and Spain. The latter country is said to be the source of the imported material, a part of which goes to England for transshipment. The total consumption by manufacturers of abrasive papers and cloth was but little over 4000 tons in 1921, with due allowance for imports and stocks carried over from the previous year. Relatively considered, the showing was as favorable probably as that of any other branch of the trade.

Despite the decline in the demand there was no radical change in the quotations for American garnet. Adirondack garnet brought $70–$90 a ton at the shipping points, with an average of about $85 for the entire sales, or nearly the same average as reported in 1921. Conditions, therefore, were not altogether unsatisfactory. It is to be noted that these prices will not hold for the rest of the domestic product and much less for the foreign, the Adirondack mineral being superior in quality to that marketed by other mines and commanding a correspondingly higher price. The Spanish garnet is the cheapest grade on the market and is said to sell at about one-half as much as the domestic product. One reason for this is the larger proportion of finer sizes in the foreign mineral, so that it does not give the full assortment required by the manufacturer. This is a point that is often ignored in the consideration of the commercial possibilities of new properties and to which the failure of some enterprises may be ascribed.

MARKETED PRODUCTION OF ABRASIVE GARNET IN THE UNITED STATES (a)
(Short tons)

Year.	Quantity.	Value.	Year.	Quantity.	Value.
1910	3814	$113,574	1916	6171	$208,850
1911	4076	121,748	1917	4995	198,327
1912	4947	163,237	1918	4600	242,400
1913	5308	183,422	1919	4944	310,131
1914	4231	145,510	1920	5476	434,425
1915	4301	139,584	1921	3048	260,687

(a) U. S. Geol. Surv.

Aside from the Adirondack section, New Hampshire and North Carolina have the only developed properties of importance, although

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occasional shipments are made from other states. Of late the mines in North Carolina have not been active, but they are capable of producing considerable quantities under favorable market conditions. In fact the developed supplies are far beyond the requirements of the manufacturing trade and are likely to remain so for years to come. One or two of the Adirondack mines could readily take care of the present demand. The market in this country seems to have reached the saturation point some time ago and the future expansion of the industry would seem to depend on the development of foreign trade, which in this particular line is now of very minor importance. The fact that garnet is a superior abrasive for certain materials has not gained any general appreciation outside of this country, as is plainly indicated by the failure of Spanish miners to find a sale for their product closer at hand.

New York.—The shippers from the Adirondack garnet district in 1920 included the American Glue Co., North River Garnet Co., H. H. Barton, and Warren County Garnet Mills, all of which reported sales also in 1921. The Warren County Garnet Mills did not operate its mine and the sales represented stocks on hand. The year's shipments amounted to about 3000 short tons as compared with a little over 4000 short tons in 1921. Prices were practically unchanged. All of the above enterprises are located within a small district which lies mainly in Warren County but extends across the Essex County line. North Creek, at the end of the Adirondack branch of the Delaware & Hudson railroad, is the central shipping point for the mineral. Some garnet has been obtained in years past from near Keeseville in northern Essex County, and from Gouverneur, St. Lawrence County, but the grade was inferior to that of the North River garnet and no sufficient demand was found for the products to warrant continuance of operations.

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ALUMINIUM AND BAUXITE

ALUMINIUM

By Robert J. Anderson

The trade and industrial stagnation continuing through 1921 affected the aluminium industry severely, as has been the case with the other major metal industries. The year just brought to a close was one of extraordinary stress and change, and the requirements of the large aluminium-consuming trades, *e.g.*, the automotive industry, were decidedly restricted. Taken by and large, the aluminium industry has not experienced such a lean year since before the war, and producers of primary aluminium, both in the United States and in foreign countries, curtailed output greatly. The world production of aluminium in 1921 was only about 35 per cent. of the actual capacity. Many secondary melters suspended operations on aluminium entirely, and the production and turnover of secondary aluminium and aluminium alloys was small. Although it is generally felt that business conditions as a whole will be considerably improved in 1922, the future aluminium situation is not even tolerably clear. The reasons for the dim outlook in the United States are not difficult to find, involving as they do the tariff situation, the depressed automotive industry, and over-capacity for the production of aluminium-alloy sand castings.

As is well known, the automotive industry is the largest consumer of aluminium (principally in the form of light alloys), and the motor business in 1921 was not any too good. However, the employment of aluminium and light aluminium alloys in motor construction is steadily increasing, and the automotive industry will probably always be a large consumer. The use of aluminium wire and cable for electrical transmission is decidedly on the increase, and now that the public-utility companies have the worst of their recent troubles behind them, and with numerous large hydro-electric projects under way or contemplated, demand for aluminium for electrical purposes should be stronger.

Although the importance of aluminium as a material for engineering construction purposes has been dwelt upon at length by those interested in the metal, and despite the impetus given to its use during the late war, its relation in tonnage output to the other important non-ferrous metals has not been generally recognized. The production of aluminium has surpassed that of tin since 1915, and has been about one-fourth that of zinc, one-fourth that of lead, and one-sixth that of copper in recent years.

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MARKET PRICES AND TRADE STATISTICS

A small revival was witnessed in demand for aluminium and manufactures thereof in the early part of 1921, over that obtaining in the closing weeks of 1920, but there was almost entire lack of buying interest thereafter. The market fell into almost total stagnation before the close of the year. Price statistics for primary and secondary aluminium, aluminium alloys, and manufactures thereof are given in the accompanying tables. The outside market prices at the opening of the year were as follows: 22–23 cts. per pound for 98–99-per cent. primary aluminium pig; 21–22 cts. for 98–99-per cent. secondary aluminium pig; and 20–21 cts. for secondary No. 12-alloy pig. Prices were at their lowest levels in the last quarter, the materials being quoted at 17–18 cts., 16–17 cts., and 14–15 cts., respectively. The net decline was 5 cts. per pound each on primary and secondary aluminium pig, and 6 cts. on secondary No. 12-alloy pig.

The Aluminum Co. of America announced reductions in its price schedule from time to time during the year. Prices for aluminium and manufactures thereof, as scheduled by this company, opened at 28.8

OPEN-MARKET PRICES OF ALUMINIUM AND ALLOYS DURING 1921, BY MONTHS

Month.	Primary Aluminium Pig, 98–99 Per Cent., Cents per Pound.	Secondary Aluminium Pig, 98–99 Per Cent., Cents per Pound.	Secondary No. 12-alloy Pig, Cents per Pound.
January	22.0–23.0	21.0–22.0	20.0–21.0
February	23.5–24.5	20.5–21.5	19.5–20.5
March	23.0–23.5	20.0–21.0	19.0–20.0
April	23.0–23.5	20.0–21.0	19.0–20.0
May	22.5–23.0	20.0–20.5	18.0–19.0
June	22.5–23.0	20.0–20.5	18.0–19.0
July	22.0–23.0	19.0–20.0	17.0–18.0
August	22.0–23.0	19.0–20.0	17.0–18.0
September	18.0–19.0	17.0–18.0	15.0–16.0
October	17.0–18.0	16.0–17.0	14.0–15.0
November	17.0–18.0	16.0–17.0	14.0–15.0
December	17.0–18.0	16.0–17.0	14.0–15.0

cts. per pound for 99-per cent. and better primary aluminium pig, 28.3 cts. for 98–99-per cent. primary aluminium pig, 27.5 cts. for No. 12-alloy pig, and 42.6 cts. base for aluminium sheet 18-gauge and heavier. These prices were held until July when reductions of approximately 3 cts. per pound each were announced. A further series of reductions of about 5 cts. per pound on the products mentioned was made in November. Prices at the close of the year were as follows: 20 cts. per pound for 99-per cent. and better primary aluminium pig; 19 cts. for 98–99-per cent. primary aluminium pig; 19 cts. for No. 12-alloy pig; and 35 cts. base for aluminium sheet 18-gauge and heavier. The average price of aluminium and manufactures thereof was the lowest in 1921 since 1914. The average price of primary aluminium pig in 1921 was 21.215 cts. per pound as against 32.72 cts. in 1920, and 18.63 cts. in 1914. In

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price, aluminium is finally back to pre-war levels, but it was the last one of the principal non-ferrous base metals to reach the normal price-level.

PRICE SCHEDULE OF THE ALUMINUM COMPANY OF AMERICA DURING 1921, BY MONTHS (a)

Month.	Primary Aluminium Pig, 99 Per Cent. and Better, Cents per Pound.	Primary Aluminium Pig, 98–99 Per Cent., Cents per Pound.	No. 12-alloy Pig, Cents per Pound.	Aluminium Sheet, 18-gauge and Heavier, Base Price, Cents per Pound.
January	28.8	28.3	27.5	42.6
February	28.5	28.0	27.3	42.6
March	28.5	28.0	27.3	42.6
April	28.5	28.0	27.3	42.6
May	28.5	28.0	27.3	42.6
June	28.5	28.0	27.3	42.6
July	25.0	24.5	24.0	39.1
August	25.0	24.5	24.1	39.1
September	25.0	24.5	24.0	39.1
October	25.0	24.5	24.0	39.1
November	20.0	19.0	19.0	35.0
December	20.0	19.0	19.0	35.0

(a) In 15-ton lots, f.o.b. producer's plant.

Aluminium coils, base price for 24-gauge and heavier, opened the year at 37.5 cts. per pound, and the price had declined to 30 cts. at the close. In the secondary market, business was exceedingly flat. Aluminium scrap and aluminium-alloy scrap were marked down to low levels, and stocks of scrap for recovery were considerably in excess of the smelting demand owing to carry-over from 1920. The range of buying and selling prices for scrap aluminium-alloy borings, scrap aluminium alloys, and scrap aluminium-sheet clippings is given in an accompanying table. Reviewing the price situation and contrasting the open-market price for primary metal against the scheduled price of the Aluminum Company of America, it is seen that the spread was quite substantial, and quite wide when ocean freight-rates, tariff, and rail-haulage to the Middle West are taken into account.

PRICES OF ALUMINIUM SCRAP AND ALUMINIUM-ALLOY SCRAP DURING 1921, BY MONTHS

Month.	Scrap Aluminium-alloy Borings, Cents per Pound.		Scrap Aluminium Alloys, Cast, Cents per Pound.		Scrap Aluminium-sheet Clippings, New, Cents per Pound.	
	Buying Price.	Selling Price.	Buying Price.	Selling Price.	Buying Price.	Selling Price.
January	7.0–10.0	8.0–11.0	16.0–18.0	18.5–20.0	19.0	21.5
February	6.5– 9.5	7.5–10.5	15.5–17.5	18.0–19.5	18.5	21.0
March	6.5– 9.5	7.5–10.5	15.5–17.5	18.0–19.5	18.5	21.0
April	6.5– 9.5	7.5–10.5	15.5–17.5	18.0–19.5	18.5	21.0
May	6.5– 9.5	7.5–10.5	15.5–17.5	18.0–19.5	18.5	21.0
June	6.5– 9.5	7.5–10.5	15.5–17.5	18.0–19.5	18.5	21.0
July	4.5– 5.0	6.5– 7.5	10.0–11.0	12.0–13.0	13.0–14.0	15.0–16.0
August	4.5– 5.0	6.5– 7.5	10.0–11.0	12.0–13.0	13.0–14.0	15.0–16.0
September	4.5– 5.0	6.5– 7.5	10.0–11.0	12.0–13.0	13.0–14.0	15.0–16.0
October	4.5– 5.0	6.5– 7.5	10.0–11.0	12.0–13.0	13.0–14.0	15.0–16.0
November	5.0– 5.5	7.0– 8.0	10.5–11.5	12.5–13.5	13.5–14.5	15.5–16.5
December	5.0– 5.5	7.0– 8.0	10.5–11.5	12.5–13.5	13.5–14.5	15.5–16.5

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Aluminium prices in Germany were exceedingly erratic in 1921, and the market varied over a wide range. Primary aluminium opened at 2600–2750 m. per 100 kg., and rolling ingots and wirebars were quoted at 2750–2850 m. (Berlin and Hamburg). Prices rose to 12,000–12,500 m. and 12,700 m., respectively, in November, and then dropped to 8300 and 8400 m. at the close. In England, primary aluminium opened at £165 for home sale and export, and dropped to £120 for home sale and £125 for export in August, holding there until the close. The actual market on aluminium and manufactures thereof, both in the United States and abroad, is still difficult to make, since the bulk of the production is sold on contract at prices that are not made public.

Production, Imports, and Exports

Producers of primary aluminium still persist in withholding information regarding their output and decline to supply other necessary and important statistics regarding the industry. Data as to the estimated world's production of aluminium, imports, exports, visible supply, etc., are given in the accompanying tables, based on the best information available to the writer. Approximate figures, revised according to the latest data available, give 28,750 metric tons as the domestic output during 1921, as compared with 90,000 metric tons in 1920. Similarly, the world output in 1921 may be taken as 74,490 metric tons, as against 146,354 metric tons in 1920. Distributing the 1921 output by producing firms, the amount of aluminium turned out by the reduction plants was as follows:

	Metric Tons.
Aluminum Co. of America, Northern Aluminium Co. of Canada	32,750
British Aluminium Co. (Great Britain and Norway)	8,000
The Aluminium Corporation, Ltd	1,000
L'Aluminium Francaise (France and Norway)	10,000
Aluminium Industrie Aktien Gesellschaft (Switzerland and Austria)	12,000
L'Aluminio Italiano (Italy)	740
German Government Works	10,000
Total	74,490

Referring now to the import-and-export movement during the past year, foreign aluminium (and manufactures thereof) was offered freely in the American market at substantial price concessions from the schedule of the Aluminum Co. of America. However, the total amount of metal brought in was about three-fourths that imported in 1920, but about twice that in 1919. The total importation of aluminium (crude, scrap, and alloys, dutiable) into the United States in 1921 was 30,577,790 lb., as compared with 40,074,132 lb. in 1920. The value of these imports in 1921 was $6,707,892, as against $11,880,176 in 1920. The value of the aluminium manufactures imported in 1921 was $2,061,577, as

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reported by the Bureau of Foreign and Domestic Commerce, as against $2,544,097 in 1920. The exportation of primary aluminium and alloys in 1921 was 1,051,833 lb. valued at $301,951, as compared with 7,381,874 lb. valued at $2,244,559 in 1920. The exports of plates and sheets in 1921 were 1,144, 545 lb. valued at $499,124, as against 2,025,757 lb. valued at $833,058 in 1920. The exports of all other manufactures of aluminium in 1921 were valued at $2,307,782, as compared with $2,563,-164 in 1920. A summary giving the production, imports, and visible supply of aluminium in the United States over a period of years and including 1921 is shown in an accompanying table. The figures given take no account of secondary and scrap aluminium and aluminium alloys.

ESTIMATED WORLD'S PRODUCTION OF ALUMINIUM
(In metric tons)

Year.	Aus-tria.	Canada.	France.	Ger-many.	Great Britain.	Italy.	Nor-way.	Switzer-land.	United States.	Total.
1913	5,000	5,916	(a)13,503	800	10,000	(a) 874	2,500	10,000	29,500	78,093
1914	4,000	6,820	(a) 9,967	800	8,000	(a) 937	2,500	10,000	40,600	82,924
1915	2,500	8,490	(a) 6,020	2,000	6,000	(a) 904	3,500	12,500	45,000	86,914
1916	5,000	8,800	(a) 9,604	8,000	4,000	(a)1,126	6,000	15,000	63,000	120,230
1917	5,000	11,800	(a)11,066	15,000	6,000	(a)1,740	8,000	15,000	90,700	164,306
1918	8,000	15,000	(a)12,023	25,000	14,000	(a)1,715	7,500	15,000	102,000	200,328
1919	5,000	15,000	(a)12,200	15,000	10,000	(a)1,673	4,000	15,000	90,000	167,874
1920	2,000	10,000	10,000	10,000	7,116	(a)1,238	4,000	12,000	90,000	146,354
1921	2,000	4,000	6,000	10,000	5,000	(a) 740	8,000	10,000	28,750	74,490
Esti-mated Capa-city....	10,000	15,000	25,000	40,000	14,000	8,000	16,000	15,000	115,000	258,000

(a) Official figures.

IMPORTS OF ALUMINIUM INTO THE UNITED STATES (a)
(By fiscal years ending June 30)

Country from Which Exported.	1915. Pounds.	1916. Pounds.	1917. Pounds.	1918. Pounds.	1919. Pounds.	1920. Pounds.	1921. Pounds.
Austria-Hungary....	264,552	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Belgium.....	194,708	*Nil.*	*Nil.*	*Nil.*	*Nil.*	44,348	37,520
Denmark.....	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	36,373	14,392
France.....	1,798,127	*Nil.*	*Nil.*	*Nil.*	2,168,963	4,703,628	814,621
Germany.....	11,133	*Nil.*	*Nil.*	*Nil.*	*Nil.*	1,919,590	3,701,052
Italy.....	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	342,195	291,477
Netherlands.....	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	13,607	55,999
Norway.....	2,046,168	*Nil.*	*Nil.*	*Nil.*	223,995	6,592,890	10,326,458
Portugal.....	4,321	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Sweden.....	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	11,023
Switzerland.....	264,552	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	5,410,448
United Kingdom....	1,675,616	21,876	120	*Nil.*	2,864,642	14,117,937	6,653,600
Canada.....	7,499,313	8,148,309	1,879,859	1,794,018	12,383,379	12,303,131	3,259,893
Mexico.....	*Nil.*	1,521	11,792	121	*Nil.*	*Nil.*	*Nil.*
Central America....	*Nil.*	528	955	38	*Nil.*	*Nil.*	*Nil.*
West Indies.....	150	2,043	6,655	5,985	2,990	433	1,278
South America.....	6,532	26,251	4,619	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Other Countries.....	*Nil.*	*Nil.*	*Nil.*	274	35	*Nil.*	29
Total.....	13,765,172	8,200,528	1,904,000	1,800,436	17,644,004	40,074,132	30,577,790

(a) Calendar years after 1917.

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PRODUCTION, IMPORTS AND VISIBLE SUPPLY OF ALUMINIUM IN THE UNITED STATES

	Production.			Imports.			Exports.	Visible Supply. (b)
				Crude.		Mfrs.		
	Pounds.	Market Value.	Per Pound.	Pounds.	Value.	Value.	Value.	Pounds.
1906	14,350,000	$5,166,000	$0.36	770,713	$154,292	$1,866	$364,251	15,121,000
1907	26,000,000	10,920,000	0.42	872,474	181,351	1,124	304,938	26,872,000
1908	13,000,000	4,095,000	0.315	465,317	80,268	2,334	330,092	13,465,000
1909	15,000,000	3,345,000	0.223	5,109,843	745,963	12,878	567,375	20,110,000
1910	12,000,000	2,736,000	0.228	12,271,277	1,844,830	(a)	949,215	24,271,000
1911	(e) 28,600,000	5,720,000	0.20	(d)4,173,308	598,272	(d)63,899	1,158,603	32,773,000
1912	(e) 40,000,000	9,200,000	0.23	22,759,937	3,092,889	428,182	1,347,621	62,760,000
1913	(e) 64,900,000	13,600,000	0.21	23,185,755	3,905,977	1,090,229	966,094	88,086,000
1914	(e) 90,000,000	16,740,000	0.186	16,241,340	2,729,383	1,308,036	1,546,510	106,241,000
1915	(e) 99,000,000	31,581,000	0.319	8,534,834	1,511,988	301,863	3,682,117	107,535,000
1916	(e)139,000,000	47,260,000	0.34	6,646,385	1,729,298	55,864	15,419,134	145,646,000
1917	(e)200,000,000	74,000,000	0.37	58,703	18,084	57,461	14,586,467	200,059,000
1918	(e)225,000,000	74,250,000	0.33	1,800,436	569,150	39,114	10,869,388	(c)202,665,000
1919	(e)198,000,000	63,756,000	0.322	17,644,004	5,810,557	318,407	3,890,326	(c)210,624,000
1920	(e)198,000,000	64,350,000	0.325	40,074,132	11,880,176	2,554,097	5,630,520	(c)228,666,000
1921	(e) 63,388,000	13,438,000	0.212	30,577,790	6,707,892	2,061,577	3,108,857	(c)92,914,000

(a) Not reported. (b) Production plus imports. (c) Exports deducted. (d) From July 1 only. (e) Estimated.

Tariff Situation

In connection with the Fordney emergency tariff bill before the legislators last year, A. V. Davis, President of the Aluminum Co. of America —the sole domestic producer—suggested that he would like to have the duty on primary aluminium pig increased from 2 cts. per pound (the present tariff under the Underwood act) to 7 cts., and that on sheets from 3½ cts. to 11 cts. Emphatic protests against this proposal were made by consumers of aluminium and aluminium alloys, both individually and collectively, and notably by the National Automobile Chamber of Commerce and by the National Aluminum Founders' Association. Consumers desire aluminium to be placed on the free list.

Those who are inclined to look into the tariff question in regard to aluminium can do so by reference to government documents,[1] and to articles and letters appearing in the technical press last year.[2] It is of interest to point out, as has been done by the National Automobile Chamber of Commerce, that the price of aluminium in the United States has been increased, in the past, in about the same proportion as the duty on foreign metal has been increased. At the moment of writing, the tariff bill had not been settled.

The new Spanish tariff came into effect May 21, 1921, by which the duty is now as follows: Aluminium in pig form: first tariff, 31 pes. 50c. per 100 kg., and second tariff, 15 pes. 75c. On aluminium bars,

[1] Hearings on General Tariff Revision before the Committee on Ways and Means, House of Representatives, Part II, Schedule C, 1921, pp. 894–928.

[2] M. Pawl, "The Tariff on Minerals," *Chem. Met. Eng.*, **24**, 1002–1008 (1921).
L. M. Brile, "The Aluminium Industry," *Metal Ind.*, **19**, 82, 124 (1921).

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sheets, tubes, and wire: first tariff, 85 pes. 50c., and second tariff, 42 pes. 75c. In Belgium, a duty has been placed on imports of fabricated and manufactured aluminium from Germany. The rates are as follows: drawn and rolled aluminium, 10 per cent. *ad valorem;* in sheets cut round to specification, 20 fr. per 100 kg. plus 10 per cent. *ad valorem.*

General Status of the Aluminium Industry in 1921

United States

The domestic industry is still dominated by the Aluminum Co. of America, which controls the mining of bauxite, the reduction of aluminium, the fabrication of aluminium and aluminium alloys, as well as the production of sand castings—the latter through its subsidiary, the Aluminum Manufactures, Inc. The output of primary aluminium in the United States was greatly curtailed, and the production of aluminium by the Aluminum Co. of America was not more than 25 per cent. of capacity. The Alcoa plant was shut down practically all year, as was also the Badin works, and the Niagara Falls and Massena plants were operated on restricted schedules. Probably less aluminium would have been turned out had the producer not had power contracts which required fulfillment.

Rumors of competitive aluminium companies in the United States are of such common occurrence that it is quite useless to pay attention to all the proposals reported. The only one that may be seriously entertained now is the Anaconda Copper Mining Co., but so far this concern has made no aluminium commercially. The International Aluminum Co., Nitro, W. Va., is said to be about to engage in aluminium production, operating on the Williams patents, which call for electrolyzing aluminium sulphate dissolved in oleum. The possibility of certain of the large copper companies entering the field is not to be questioned, since aluminium has become a dangerous competitor for copper in both alloy castings and in electrical work. Henry Ford made overtures to the War Department during the past year for taking over the Muscle Shoals nitrate project. The plant could be readily adapted to the production of aluminium, and if so operated would mean competition in the domestic industry.

The production of aluminium-alloy castings in the United States was substantially curtailed in 1921, owing largely to the slump in the automotive industry. Production of cast parts for vacuum cleaners was low. The Aluminum Manufactures, Inc., the various large independent foundries of the National Aluminum Founders' Association, and the foundry departments of motor-car builders have been operating at not over 50

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per cent. of capacity. The capacity of the Aluminum Manufactures, Inc., is at least 30,000,000 lb. per annum, while the other independent and automotive foundries have a combined capacity of about 60,000,000 lb. of finished castings. There appears to be an over-capacity in the United States for sand castings. Die-casting output in 1921 was small. The cooking-utensil industry in the United States has held up well despite the heavy importation of German and Swiss utensils. Retail prices of aluminium cooking utensils were the lowest seen in years. The consumption of so-called bronze powder for use in painting, and that of aluminium foil for wrapping purposes, was reduced. The consumption of aluminium in steel practice for deoxidizing was about 40 per cent. of normal, owing to the heavy slump in steel output, and that of granulated aluminium for thermit purposes and for the reduction of ferro-alloys was also low. There has not been any general demand for aluminium wire and cable, but such conductors were purchased in the past year for the largest projects under construction. One copper-wire maker stated that he had lost a $5,000,000 order for transmission wire because the competitive bid on aluminium wire was lower.

The Baush Machine Tool Co., Springfield, Mass., has made good progress in the rolling and forging of duralumin, and experiments are under way on the use of duralumin connecting rods for automobile motors. Collapsible aluminium tubes are being made at the Edgewater, N. J., plant of the Aluminum Co. of America, but that plant was largely shut down last year. A decree of the Federal Trade Commission ordered the Aluminum Co. of America, under the anti-trust law, to dispose of all stock held by it in the Aluminum Rolling Mill Co., Cleveland, O.

The Bureau of Mines continued its investigative work in the metallurgy of aluminium at its Pittsburgh Station. The appropriation of $30,000 requested from Congress for the expansion of this work was rejected. There have been no new developments in the United States in a technical way that had any marked effect on the trade, but there appear to be important possibilities imminent as the result of investigative work in progress.

Foreign Countries

The foreign aluminium industry has not changed substantially in its relation to the domestic industry during the year just brought to a close, but several foreign countries where aluminium is not now being made are much interested in establishing works for the manufacture of the metal. In certain countries, *e.g.*, Japan, India, and Australia, where the consumption of aluminium in the form of manufactures is now fairly substantial, it appears that local aluminium-reduction plants would be

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commercially successful. The general remarks made above as to the industrial status of the aluminium industry in the United States apply on the whole to the foreign countries where any substantial aluminium industry exists.

Australia.—Inquiries have been set up by the Commonwealth Bureau of Commerce and Industry concerning the possibility of the commercial production of aluminium in Australia. Deposits of bauxite in this country have been investigated, especially one at Wingello, near Moss Vale, N. S. W., and about 4,000,000 tons of ore has been proved. The provincial Government is much interested in the possibility of starting an aluminium industry, and the matter is now in process of investigation.

France.—The production of aluminium in France in 1921 was greatly curtailed, being probably not more than 25 per cent. of capacity, although official figures are not yet available. Exports to the United States were only one-sixth of those in 1920. France will continue, of course, as a leading producer of aluminium owing to the advantage in possessing mines located near hydro-electric power plants and of having excellent sources of bauxite. Although the French bauxite production has been relatively low in recent years as compared with the output prior to the war—when much of it went for export—it is thought, according to reliable opinion, that the output for French consumption will increase up to 200,000 metric tons per year.

A national exposition for aluminium was held last year under the direction of La Société d'Encouragement pour l'Industrie nationale, which is described by Guerin.[1] The August and September, 1921, issues of *Revue de Métallurgie* are devoted largely to papers on aluminium and aluminium alloys, and a detailed account of the exposition is given. The French aluminium industry is operated under the selling agency L'Aluminium Francaise, including the following companies; Compagnie des produits chemiques d'Alais et de la Camargue; Société Electrometallurgique Francais; Société d'Electrochemie; Société des Forces Motrices de l'Arve; and Société Electrometallurgique de Pyrenees. The control of 90 per cent. of the industry is in the hands of the first-mentioned producer.

Germany.—Many conflicting reports, evidently of German origin, have been issued recently as to the status of the aluminium industry in Germany, but probably the most reliable and recent information is contained in a paper by Sterner-Rainer.[2] Prior to the war, the only aluminium-reduction plant was the Rheinfelden works in Baden, with

[1] R. Guerin, "Compte rendu général de l'Exposition de l'aluminium," *Rev. de Mét.*, **18**, 539–558 (1921).
[2] R. Sterner-Rainer, "Gegenwart und Zukunft der deutschen Aluminiumindustrie," *Zeit. für Metallkunde*, **13**, 353–364 (1921).

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an annual output of 800 tons. Owing to the war demand for metal, additional plants were established at Rummelsburg (near Berlin), at Horrem (Cologne), at Bitterfeld, at Grevenbroich (on the Erft), and in Lausitz (the Lautawerke). The former Austria Government established the Steeg works near Goisern on Lake Hallstaedt, Austria. The Inn works at Mühldorf, Bavaria, is now in the course of construction, but it will not be in operation until a few years hence.

The Rummelsburg and Horrem works have been closed, so that production, apart from the Rheinfelden plant, is restricted to the Bitterfeld, Grevenbroich, and Lauta plants, the former with a capacity of 4000 tons annually and the latter two 14,000 tons each. It is of interest to point out that all aluminium-reduction plants established in Germany during the war are supplied with electric current from lignite-fired boiler plants, with the sole exception of the Inn works, for which a hydro-electric scheme has been projected. The existence of the German works appears to be somewhat precarious, and although Germany can, no doubt, maintain her position in aluminium manufactures, it is doubtful that the primary aluminium plants can survive. The reasons for this view are as follows: (1) With the exception of the Rheinfelden works, the plants were constructed more for the needs of the moment than with an eye to the future, and consequently steam-power was installed instead of water-power; (2) Germany is only a small producer of bauxite, and during the war used ore from Istria, Transylvania, Dalmatia, and the islands in the Adriatic, and stocks are now quite low; (3) most of the available water-power is in the south, and it is doubtful whether it is an economical procedure to transfer the works from their present sites to the water-power region. Hard attempts have been made, however, to establish plants in southern Germany where Alpine water-power is available, but the Inn works, with which the Allgemeine Elektricitaats Gesellschaft and Siemenhs-Scuckert are associated, is the only one under construction. The output of aluminium in Germany was about 10,000 metric tons, as referred to a capacity of about 40,000 metric tons.

It has been hinted that there is a group in Germany which would restrict imports of copper from the United States in order to foster the German aluminium industry. A committee of the Deutsche Gesellschaft für Metallkunde conducted an inquiry into the results of using aluminium electrical conductors in place of copper—a measure widely adopted in Germany during the war. The report states that where the proper precautions are taken in erecting and maintaining wires, aluminium overhead conductors are thoroughly satisfactory. The Zeppelin works at Staaken has now placed on the market motor-boats made entirely of duralumin; it is proposed to use such boats as life-boats on ships.

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Great Britain.—The industrial crisis affected the aluminium industry severely in England in 1921, and the output was about one-third of the capacity. Exports of primary aluminium pig to the United States were less than one-half those in 1920. The industry is dominated by the British Aluminium Co., Ltd., which controls plants in England and in Norway at Stangfjorden and at Vigeland, through the Anglo-Norwegian Co. Metallurgical research work on light aluminium alloys has been carried out at the National Physical Laboratory for a number of years, and the results have been of great value to the industry. The Imperial Mineral Resources Bureau issued a report[1] on aluminium and bauxite, covering the years 1913–1919.

Italy.—Information emanating from Italy on the industry there has been exceedingly scant during the past year. Reports have been issued that the Italian Government intended purchasing the bauxite deposits near Abruzzi and Tamnium in connection with the proposed electrification of the railways, for which a large amount of copper would be required unless aluminium were used. Since Italy is obliged to import copper, aluminium is likely to be substituted wherever possible. But little aluminium, or manufactures thereof, is exported from Italy; although the amount exported has increased recently, the imports still exceed the exports. In 1919, of a production of 1673 metric tons, 282 tons was exported, but imports were 1602 tons. In 1920, of a production of 1238 tons, 754 tons was exported, while imports were 1054 tons. Production in 1921 amounted to 740 metric tons; the figures for imports and exports are not yet available.

India.—Plans are under consideration for the construction of an aluminium-reduction plant on the west coast of India, to produce about 2500 tons of aluminium per annum, using hydro-electric power and Indian bauxite. It is proposed to generate 20,000 kw. Considerable amounts of aluminium are now being imported into India for the manufacture of utensils, and it is thought that there would be a good market for the metal and demand for any surplus power.

Japan.—Japanese Government investigators have been working on methods for the manufacture of aluminium from Korean and Japanese aluminiferous minerals. It is reported that a subsidized company is to establish a plant at Yoyogi, using hydro-electric power. The question of the establishment of an aluminium industry in Japan is one of great concern to that country in connection with its aviation program. The Asiatic Aluminum Co., with an authorized capital of 100,000 yen, has been established at Tokio for the sale of the products of the Aluminum Co. of America.

[1] Anon., "Aluminium and Bauxite," Imperial Mineral Resources Bureau, H. M. Stationery Office, London, 1921.

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Norway.—Norway appears to be the logical country for the future expansion of the European aluminium industry, so long as the electrolytic process is employed, since water-power is exceptionally cheap and shipping facilities are good. From one works in 1907 with a production of 400 tons, rated at 1800 kw., the industry has increased to five plants and a total power installation of about 60,000 kw. with a capacity of about 16,000 tons per year. Actual production in Norway was only about 50 per cent. of capacity in 1921, but still at least twice that in 1920. The production of primary aluminium pig has been, so far, largely for export, and the local consumption is small. In 1921, Norway shipped 10,326,458 lb. of aluminium to the United States. The works are operated by British, French, and Norwegian interests. Saeter[1] has discussed the aluminium industry in Norway.

Switzerland.—Information on the Swiss aluminium industry is always difficult to obtain, although Switzerland is one of the leading producing countries. The Aluminium Industrie Aktien Gesellschaft with plants in Switzerland, Germany, and Austria is the chief company of the Central Powers, with an estimated capacity of 15,000 metric tons per annum. Imports of aluminium pig from Switzerland to the United States in 1921 were 5,410,448 lb., marking the resumption of importation since 1915. Large quantities of Swiss aluminium cooking utensils were exported to various markets in 1921. New patents taken out in Switzerland for eliminating aluminium oxide in autogenous welding by means of a solvent in the form of a powder are now being worked by the Compagnie de Soudure autogene d'aluminium of Zurich.

Technology of Aluminium and Aluminium Alloys

Owing to the interest displayed in recent years in aluminium and its light alloys by the general engineering trades, a considerable amount of fundamental investigative work has been commenced in a number of directions with a view to obtaining more definite data. In the United States, research work on the application of aluminium to aircraft is being carried out by the War Department, and studies of waste prevention in the industry are being conducted by the Bureau of Mines.

Joseph W. Richards, the well-known American authority on aluminium metallurgy, died Oct. 12, 1921. He was the author of "Aluminium, its Properties, Metallurgy, and Alloys,"[2] the first and most extensive book in English on aluminium; the preparation of a fourth edition of this work was interrupted by his death. He had also for many years contributed the annual chapter on aluminium to Mineral Industry.

[1] H. B. Saeter, "The Aluminium Industry in Norway," *Metal Ind.*, **19**, 150 (1921).
[2] H. C. Baird & Co., Philadelphia, 1896 (3rd edition).

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The atomic weight of aluminium has been revised from the old value 27.1 to 27.0. Richards and Krepelka[1] in a recent series of experiments have determined the value as 26.963. Little progress has been made in specifications for aluminium and aluminium alloys, and the status of the situation is exceedingly unsatisfactory. Tentative specifications for light aluminium casting alloys, aluminium sheet, aluminium ingots for rolling, and aluminium for use in deoxidizing steel have been prepared by the American Society for Testing Materials. Aluminium is still sold on the basis of the difference method of analysis (where copper, iron, and silicon are determined, and the remainder is said to be aluminium). This method is exceedingly unsatisfactory to consumers, and the writer has criticized it adversely time and again since it gives a fictitious value and is no criterion of quality. A method for the direct determination of aluminium has been worked out in the Bureau of Mines by Capps,[2] based on the measurement of the hydrogen evolved when the metal is attacked with a suitable reagent. No subject in the metallurgy of aluminium is in a more unsatisfactory state than the analysis of the metal, and the problem is one of great practical and scientific importance.

The domestic production of bauxite fell from 521,308 long tons in 1920 to about 140,000 tons in 1921, a decrease of about 381,000 tons. On the basis that 25 per cent. of the output is diverted to purposes other than for the reduction of aluminium, the remainder would reduce to about 24,000 long tons of metallic aluminium or 53,760,000 lb. This takes no account of imports of bauxite. On this basis, this figure arrived at is about one-fourth of the 1920 output for aluminium, which agrees well with the estimated figure given in the tables of production arrived at by other means.

Alumina and Aluminium Nitride.—The orthodox methods for the preparation of alumina are still in vogue, but further attention has been given to the various nitride processes, some of which look quite promising. In Germany, pure alumina, as a basis for aluminium manufacture, has been produced from clays. The usual patents for the preparation of alumina from aluminiferous minerals were brought out, but nothing of apparent importance was developed. Sem[3] has patented a process for the electrolytic production of low-iron aluminium oxide, in which aluminium sulphate is electrolyzed, yielding $Al(OH)_3$ which is subsequently calcined.[4] Schoeld has patented a process for the manufacture of aluminium nitride, while several patents on this subject have been granted to Hoopes.[5]

[1] T. W. Richards and H. Krepelka, "A Revision of the Atomic Weight of Aluminium. The Analysis of Aluminium Bromide." Preliminary Paper, *Jour. Am. Chem. Soc.*, **42**, 2221–2232 (1920).
[2] J. H. Capps, "Determination of Metallic Aluminium and of Aluminium Oxide in Commercial Metal," *Jour. Ind. Eng. Chem.*, **13**, 808–812 (1921).
[3] U. S. Pat. No. 1,382,808, June 28, 1921.
[4] Canadian Pat. No. 210,713, Apr. 19, 1921.
[5] U. S. Pat. Nos. 1,393,370; 1,393,371; 1,393,372; and 1,393,373, Oct. 11, 1921.

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Reduction of Aluminium.—The Aluminum Co. of America has been experimenting at its Badin plant on the production of aluminium directly from bauxite, omitting the intermediate step of preparing alumina. The results are reported to be encouraging. Practically pure (99.96 per cent. Al, by difference) aluminium has been made on a semi-commercial scale by the same company. Stevens[1] specifies the reduction of aluminium from its ores by heating, out of contact with air, a mixture of ore, sodium chloride, and a carbonaceous substance, with or without the addition of an oxalate formed preferably by the inclusion of sawdust and an alkali in the mixture. Williams[2] has patented a process in which an aluminium compound, such as aluminium sulphate, is dissolved in oleum and electrolyzed. It is understood that the International Aluminum Co. is to operate on this patent. Tucker[3] has devised a method for refining aluminium.

Aluminium Chloride.—The possibility of a large aluminium-chloride industry is not to be overlooked, and much work has been carried out in recent years on the preparation of aluminium chloride for use in cracking oils. Alexander[4] has patented a process in which a finely ground mixture of aluminium oxide and carbon is treated with a mixture of chlorine and air at a temperature of 1600° to 2000° F. Baum and Jones[5] have patented the use of aluminium nitride as a cheap source of aluminium for making aluminium chloride. According to patents by Booth and Marshall,[6] aluminium chloride is made by treating aluminium silicate in an electric furnace with calcium chloride.

Corrosion and Coatings.—The Corrosion Committee of the Institute of Metals is continuing its work on the corrosion of aluminium and its light alloys, and valuable data have been accumulated as the result of its investigations. A number of the usual patents for coating aluminium with other metals and other metals with aluminium appeared, but lack of space prevents citing them. The employment of calorized parts of copper, brass, and steel is gaining ground, and considerable interest is being taken in the use of calorized parts by the engineering and metallurgical trades. Calorized condenser tubes have been investigated, and aluminium-coated fire bars have been tried successfully in Germany on locomotives. The applications of calorized parts and the methods of calorizing have been discussed by Farr.[7]

Fabrication.—A three-high mill for breaking down ingots has been designed, and it is reported that it will be built for an independent rolling mill in the United States.

[1] British Pat. No. 160,760, Feb. 14, 1921.
[2] Canadian Pat. No. 211,244, May 4, 1921; see also U. S. Pat. No. 1,351,144, Aug. 31, 1920.
[3] U. S. Pat. No. 1,384,499, July 12, 1921.
[4] U. S. Pat. No. 1,366,626, Jan. 25, 1921.
[5] U. S. Pat. No. 1,372,332, Mar. 22, 1921.
[6] U. S. Pat. Nos. 1,392,043; 1,392,044; 1,392,045; and 1,392,046, Sept. 27, 1921.
[7] A. V. Farr, "Calorising as a Protection for Metals," *Iron Age*, 107, 251–253 (1921).

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Properties.—Carpenter and Elam[1] have studied further the effect of heating worked aluminium sheet and have added considerably to the available knowledge on this subject.

Uses.—The employment of aluminium for electrical transmission is being regarded with more favor yearly, and in 1921 aluminium wire was available at lower cost than copper wire. Aluminium conductors have been employed extensively in Germany. The use of aluminium in the electrical industry in France has been investigated and a report issued.[2] Aluminium is being put to an increasing number of uses yearly, and, with lower prices in the future, the demand may be expected to increase enormously.

Technology of Light Alloys

Foundry Practice.—The tendency in the use of light alloys in foundry practice in recent years has been toward the development of definite alloys for particular purposes, and while the standard 92:8 aluminium-copper alloy is still generally used for most castings, a number of special alloys have gained prominence. The question of casting losses in light-alloy founding has been investigated at length by the writer,[3] and it has been found that the monetary losses involved owing to the production of wasters and defective castings is now at the rate of $1,200,000 per annum in the United States, of which at least $600,000 could be saved if the readily avoidable defects were prevented.

In the case of new installations of furnaces for melting aluminium alloys in foundry practice, the tendency is toward large units, up to 3000 lb. capacity. Reverberatory or open-hearth furnaces, large cylindrical-shaped furnaces, and electric furnaces are coming in for considerable attention. The question of oxidation losses in the preparation and melting of aluminium alloys has been investigated by the Bureau of Mines,[4] and the monetary loss involved is at the rate of $3,000,000 per annum in the United States. Iron-pot melting practice for aluminium alloys in foundry work has been investigated by the writer.[5] In connection with studies of melting losses, the constitution of the atmospheres in a variety of typical furnaces has been investigated by the writer and J. H. Capps.[6]

[1] H. C. H. Carpenter and C. F. Elam, "Stages in the Recrystallization of Aluminium Sheet on Heating, with a Note on the Birth of Crystals in Strained Metals and Alloys," *Jour. Inst. Metals*, **25**, 259–280 (1921).

[2] Bureau de la Revue générale de l'électricité, "L'aluminium dans l'industrie électrique, rapports de la XV commission de l'union des syndicate de l'électricité," Paris, 1921.

[3] R. J. Anderson, "Casting Losses in Aluminium-foundry Practice," *Trans. Am. Foundrymen's Assoc.*, **29**, 459–487 (1921); and "Analyze Loss in Aluminium Shops," *Foundry*, **48**, 989–992 (1920); and *idem.*, **49**, 16–21, 54–57, 104–111, 143–147, 188–191, and 235–239 (1921).

[4] R. J. Anderson, "Losses in Aluminium and Aluminium-alloy Melting," *Bur. of Mines Rept. of Investigations*, Serial No. 2239, April, 1921.

[5] R. J. Anderson, "Iron-pot Melting Practice for Aluminium Alloys," *Metal Ind.*, **19**, 189–190, 246–247, 285–287, 360–362, 397–399 (1921); and others to appear.

[6] R. J. Anderson and J. H. Capps, "Gases in Aluminium Furnaces and Their Analysis," *Chem. Met. Eng.*, **24**, 1019–1021 (1921); and "Constitution of Gas Atmospheres in Aluminium-alloy Melting Furnaces," *ibid.*, **25**, 54–60 (1921).

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Patents for treating porosity in aluminium-alloy castings have been taken out by Norton[1] and by Bezzenberger and Rich.[2]

Heat-treatment.—The results of heat-treating duralumin and its related alloys have aroused interest in the possibilities of heat-treating cast aluminium alloys, and while practically no castings are now heat-treated commercially, experiments in this direction are promising.

Lavandeyra[3] has patented an alloy which is said to be particularly susceptible to heat-treatment and adapted to working; the nominal composition is 96 : 2.5 : 0.5 : 0.5 : 0.5 Al-Cu-Cr-Mg-Mn. Blough[4] has patented alloys of the duralumin type.

Metallurgy and Metallography.—In three important papers, Edwards[5] and his collaborators have supplied data of much practical and scientific value as regards the density of aluminium and some aluminium-copper alloys in the solid and liquid states. It was found that the density of 99.75-per cent. aluminium (by difference method of analysis) is 2.703 at 20° C. and 2.289 at 1000° C., and that the density drops from 2.55 to 2.382 on passing from the solid to the liquid state at the melting point. Hanson and Gayler[6] have discussed the constitution of some alloys of the duralumin type in the system aluminium-magnesium-silicon. Waehlert[7] has dealt with the light ternary alloys of aluminium with copper and zinc, with copper and tin, and with iron and zinc, containing up to 12 per cent. of the added metals. Schulte[8] has studied the effect of small amounts of cerium on the properties of aluminium and some light alloys. To cerium is ascribed the rôle of removing nitrogen combined as aluminium nitride, but the results appear open to serious question.

Houghton and Bingham[9] have studied the constitution of ternary aluminium-copper-zinc alloys at the zinc corner of the diagram. Rosenhain[10] and his co-workers in the Eleventh Report to the Alloys Research Committee of the Institution of Mechanical Engineers have submitted an extended discussion of the properties of a number of light aluminium alloys, including those of the duralumin type. This report covers largely the alloy development work in Great Britain during the war, and is a

[1] U. S. Pat. No. 1,384,033, July 5, 1921.
[2] U. S. Pat. No. 1,383,517, July 5, 1921.
[3] U. S. Pat. No. 1,365,178, Jan. 11, 1921.
[4] U. S. Pat. No. 1,394,534, Oct. 25, 1921.
[5] J. D. Edwards, and T. A. Moorman, "Density of Aluminium from 20 to 1000 Deg. C.," *Chem. Met. Eng.*, **24**, 61–64 (1921); see MINERAL INDUSTRY, **29**, 17 (1920).
J. D. Edwards, "Mechanism of Solidification of a Copper-aluminium Alloy," *Chem. Met. Eng.*, **24**, 217–220 (1921).
J. D. Edwards, and H. T. Gammon, "Causes of Piping in Aluminium Ingots," *Chem. Met. Eng.*, **24**, 217–220 (1921).
[6] D. Hanson, and M. L. V. Gayler, "The Constitution and Age-hardening of the Alloys of Aluminium with Magnesium and Silicon," *Jour. Inst. Metals*, **26**, 321–355 (1921).
[7] M. Waehlert, "Über ternäre Aluminium legierungen," *Metall u. Erz*, **18**, 298–307 (1921).
[8] J. Schulte, "Über den Einfluss des Cers auf die Eigenschaften des Aluminiums und einigen wichtiger Legierungen von Leichtmetallen," *Metall u. Erz*, **18**, 236–240 (1921).
[9] J. L. Houghton, and K. E. Bingham, "The Constitution of the Alloys of Aluminium, Copper, and Zinc Containing High Percentages of Zinc," *Proc. Royal Soc.*, **99A**, 47–68 (1921).
[10] W. Rosenhain, S. L. Archbutt, and D. Hanson, "Eleventh Report to the Alloys Research Committee: on Some Alloys of Aluminium (Light Alloys)," *Inst. Mech. Engrs.*, August, 1921.

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worthy successor to the prior reports to the same committee. The work cannot be reviewed here even in a brief way, but the publication should be of great value to those interested in light alloys.

The writer[1] has described the use of ferric sulphate for distinguishing between $CuAl_2$ and $FeAl_3$ in the microscopy of light aluminium-copper alloys, and in another paper[2] the macrography of aluminium-alloy castings has been dealt with. The manufacture, properties, and uses of aluminium-copper alloys have been described,[3] and an extensive bibliography on the subject given. Schulze[4] has measured the thermal expansion of aluminium-zinc alloys in the temperature range 20° to 400° C. A number of papers by Grard, Guillet, Fleury, and others on light aluminium alloys appear in the August and September issues of *Revue de Métallurgie*, and Guillet[5] has published a bibliography on aluminium and its alloys.

A development worthy of especial note is that of the aluminium-silicon alloys brought out by A. Pacz in the United States; these are of considerable potential importance and have attracted great interest in the industry. Pacz has taken out a number of patents relating to the preparation of these alloys and the use of fluxes for enhancing the physical properties. The alloys, *e.g.*, 87:13 Al-Si, may be made[6] by simply adding solid silicon to liquid aluminium and then treating with a suitable flux such as an alkali fluoride. In another patent,[7] it is suggested that the alloys be made by the reduction of a double fluoride of sodium and silicon, *i.e.*, Na_2SiF_6 with aluminium. Other patents[8] have been taken out by Pacz relating to the same subject. It appears that the use of a flux is essential for producing fine-grained and strong alloys. The 87:13 Al-Si alloy when prepared according to the methods preferred has an ultimate strength of 30,000–32,000 lb. per sq. in. and elongation of 6 to 11 per cent. A metallurgical departure of great importance would be made if aluminium-silicon alloys could be produced directly from clays or aluminium silicates.

Welding and Soldering.—It is of interest to direct attention to the outcome of the recent suit of the Aktien Gesellschaft für Autogene Aluminium Schweissung *vs.* the London Aluminium Co., Ltd., in England in a controversy over the Schoop patents. The former brought suit to

[1] R. J. Anderson, "Ferric Sulphate as a New Etching Reagent in the Metallography of Aluminium," *Metal Ind.*, **19**, 69–70 (1921).
[2] R. J. Anderson, "Castings of Light Aluminium Alloys," *Iron Age*, **107**, 433–436 (1921).
[3] R. J. Anderson, "Aluminium-copper Alloys," paper before the Am. Electrochem. Soc., Fall Meeting, 1921, Lake Placid, N. Y.; *Trans. Am. Electrochem. Soc.*, **40**.
[4] A. Schulze, Über die Wärmeausdehnung der Aluminium-Zink-Legierungen," *Physik. Zeitsch.*, **22**, 403–406 (1921).
[5] L. Guillet, "Bibliographie de l'aluminium et de ses alliages," *Rev. de Mét.*, **18**, 517–520 (1921).
[6] British Pat. No. 158,827, Jan. 26, 1921.
[7] British Pat. No. 160,426, Mar. 18, 1921.
[8] British Pat. No. 160,427, Mar. 18, 1921; Canadian Pat. No. 209,696, Mar. 22, 1921; and U. S. Pat. No. 1,387,900, Aug. 16, 1921.

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restrain infringement of the patents, but the case was dismissed on the ground of no infringement. Heyes[1] has discussed the electric arc welding of aluminium and Andrews[2] has dealt with the methods in use for joining aluminium and aluminium-alloy parts.

Uses.—While light aluminium alloys are being employed to an increasing extent for construction purposes throughout the engineering trades, the largest use continues to be for automotive castings. The employment of aluminium-alloy pistons in internal-combustion engines is still in the throes of debate by automotive engineers, but the makers of pistons have made marked advances in the past two years. Pannell[3] has discussed the use of aluminium-alloy pistons in internal-combustion engines. An occurrence of the utmost importance in air-craft circles last year was the failure of the ZR-2 dirigible during its trial flight. This catastrophe cast a pall over dirigible air-craft development work, and to some extent also over the aluminium alloys for construction purposes. So far as the available evidence is able to show, the fault in this and similar dirigible failures should not be ascribed to the use of aluminium alloys, but rather to poor design involving structural weaknesses. The use of aluminium alloys for automotive work in Germany has been discussed by von Selve,[4] and he mentions the use of pistons made from a low-copper-content aluminium alloy by pressing and drawing in the same manner as with cartridge cases; connecting rods in aluminium alloys are said to be employed successfully. Duralumin is suggested by the Bausch Machine Tool Co. as a material for gears, and it is reported that a considerable number of duralumin worm wheels are now in regular service in the United States on trucks of from 1 to 3½ tons capacity. The use of an alloy of the nominal composition 94:4.5:0.5 Al-Cu-Mg is patented by Babson[5] for gears, to be worked and heat-treated.

BAUXITE

BY T. POOLE MAYNARD

Bauxite is a hydrated oxide of alumina carrying also iron oxide, silica, titanium clay, etc. Bauxite varies in its physical character from a structure resembling that of fish roe to that of a marble, and it is sometimes amorphous.

EVERHART PATENTS

The most important development as a result of research during 1921 is the Everhart process of concentrating low-grade bauxite. The altera-

[1] F. J. Heyes, "Electric Arc Welding Applied to Aluminium," *Mech. Wld.*, **69**, 181–182 (1921).
[2] E. Andrews, "Joining Aluminium Parts," *Am. Mach.*, **54**, 167E–172E (1921).
[3] E. V. Pannell, "Aluminium-alloy Pistons," *Metal Ind.*, **19**, 15–17 (1921).
[4] W. von Selve, "Neue Erfahrungen mit Leichtmetallen in schnellaufenden Motoren," *Zeit für. Metallkunde*, **13**, 316–318 (1921).
[5] U. S. Pat. No. 1,371,214, Mar. 15, 1921.

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tion of clays into bauxite ordinarily has been so gradual that the slight distinction in the two materials imposes great difficulty in their separation in the process of concentration. In the study of many bauxitic clays, Dr. Edgar Everhart has demonstrated that this physical difference is sufficiently marked, however, to allow of satisfactory separation by washing in the presence of small amounts of added peptizers. This makes possible the recovery of bauxite from two types of deposits hitherto not considered of commercial interest.

The first type embraces those deposits carrying granular high-grade ore mixed with varying grades of low-grade ore, where the proportion of clayey impurities varies from as low as 2 to 1 to where the proportion of clay to bauxite is as much as 7 to 1.

The second type of deposits made available are the low-grade bauxites and bauxitic clays carrying from 42 to 52 per cent. alumina, which deposits are not now considered of commercial value, but which can be concentrated to from 55 to 58 per cent. alumina, with a loss of clayey impurities varying from 25 to 45 per cent.

The results of the process on this type of ore are as follows:

	Crude Ore, Per Cent.	Concentrated Ore, Per Cent.
Alumina (Al_2O_3)	48.87	57.85
Silica (SiO_2)	24.39	11.60
Iron oxide (Fe_2O_3)	2.94	1.76
Titanium dioxide (TiO_2)	2.13	2.13

Bauxite from a wide range of localities has been tried out by this process. The most successful commercial peptizers used are sodium hydroxide and the more strongly absorbed sodium salts. Patents have been granted covering the use of the above materials and process. A curious phenomenon observed in connection with these experiments is that in a few of the highly aluminous clays sulphuric acid, which usually acts as a coagulant, appears in the rôle of a peptizer in certain low concentrations. Another feature of very great commercial importance is that the iron and titanium oxides contained in the clay substance are not precipitated with the alumina, but are washed out with the clayey impurities. This makes available for the chemical industries as well as for the manufacture of aluminium an ore high in alumina and at the same time very low in iron and titanium.

The use of the process does not involve any particular type of machinery. It can be adapted to the wide variety of washing and concentrating machinery now on the market. As this process of concentrating bauxite is the converse of the present system of clay washing, the clays can very readily be recovered in the refined condition and used in suitable by-products. Extensive tests have shown that this method of concentration

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can be applied with success to a wide variety of low-grade bauxites in the three great fields in this country. While certain indurated and more silicious ores are not susceptible to treatment, there remains a broad field of application.

The application of these methods can make possible the use of mechanical equipment in mines, save much of the wasted overburden, and make commercial many of the underlying bauxitic clays, thereby making available immense deposits so low in alumina that they have never been opened.

United States Deposits

Our commercial bauxite deposits are found in central Arkansas, northeast Alabama, southeast Alabama, northwest Georgia and the central and southwest portions of that State, south central Tennessee and northeast Tennessee. The Arkansas field yields about 90 per cent. of the bauxite produced in the United States. Two new areas of bauxite were found in 1921 and 1922; one of these areas is in northeast Mississippi and the other is in Barbour County, Alabama.

The bauxites which are found in the Coastal Plain area in this country are of very great commercial promise. Many of these low-grade ores are susceptible to concentration and with the possibility of obtaining ores high in alumina and low in iron and silica as the result of concentration they have a wide field for use in the chemical industries.

The extensive deposits of low-grade bauxite and bauxitic clays found in the area traversed by the Central of Georgia Railway will be found particularly desirable for use in the manufacture of super-refractories. Experiments are now being carried on by the Industrial Department of the Central Georgia Railway in coöperation with the United States Bureau of Mines with the view of determining the commercial feasibility of the manufacture of high-grade refractories from this clay.

The bauxite deposits of Alabama and Tennessee are similar in the nature of their occurrence and origin to the deposits of Georgia. The Alabama area extends from the vicinity of Piedmont in a general northeast direction to Cave Springs, Ga., striking across Georgia in the same direction to the vicinity of Chattanooga, Tenn.

Production of Bauxite in 1921

The production of bauxite in the United States for 1921 is estimated by the United States Geological Survey at 139,550 long tons. This is not much more than one-fourth of the production in 1920. The great decrease was due to lack of demand from all consuming industries. The production from the Arkansas field was only 124,850 tons in 1921, and

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this field has produced as much as 570,000 tons in a year. The Eastern States produced only 14,700 tons as compared with a maximum production of 62,100 tons. Georgia produced 10,174 tons and Alabama and Tennessee each contributed a small tonnage to the Eastern States total.

PRODUCTION OF BAUXITE IN THE UNITED STATES BY STATES
(In tons of 2240 lb.)

State	1913. (a)	1914. (a)	1915. (a)	1916. (a)	1917. (a)	1918. (a)	1919. (a)	1920. (a)	1921. (a)
Alabama....	27,409	18,547	25,008	46,410	62,134	42,829	43,076	40,029	14,700
Georgia....									124,850
Tennessee ..	182,832	200,771	272,033	378,949	506,556	562,892	333,490	431,279	
Arkansas ...									
Total.....	210,241	219,318	297,041	425,359	568,690	605,721	376,566	521,308	139,550

(a) Statistics of the U. S. Geol. Surv.

Uses

Bauxite is used in the manufacture of aluminium, for abrasives, alum, aluminium sulphate, refractories, and various other salts of aluminium. The bauxites which are used in the manufacture of aluminium are obtained chiefly from the Arkansas deposits, while ores used largely in the manufacture of chemicals are obtained from the Georgia-Alabama and Tennessee deposits on account of the low content of iron characteristic of these ores. A considerable tonnage of bauxite is used in the manufacture of artificial abrasives and there is a wide field for the manufacture of super-refractories from the extensive deposits of bauxitic clays found in Georgia and Alabama.

CONSUMPTION OF BAUXITE IN THE UNITED STATES (a)

Year.	Production.			Imports.		Consumption.	
	Long Tons.	Value.	Per Ton.	Long Tons.	Value.	Long Tons.	Value.
1910.....	149,679	$778,203	$5.33	15,720	$65,743	164,601	$782,001
1911.....	155,618	750,649	4.87	43,222	164,301	198,840	914,950
1912.....	160,124	900,620	5.00	26,214	95,431	186,079	864,363
1913.....	210,241	997,698	4.75	21,456	85,746	231,697	1,083,444
1914.....	219,318	1,069,194	4.87	24,844	96,500	238,788	925,610
1915.....	297,041	1,514,834	5.10	3,420	17,107	284,379	814,755
1916.....	425,100	2,296,400	5.40	30	87	407,191	1,309,033
1917.....	568,690	3,116,421	5.48	7,691	28,989	554,590	1,824,121
1918.....	605,721	3,447,992	5.69	3,653	14,791	589,663	1,939,095
1919.....	376,566	2,201,747	5.85	6,082	36,820	364,947	766,473
1920.....	521,308	3,247,345	6.23	42,895	408,485	541,946	1,812,234
1921.....	139,550	889,800	6.38	27,587	164,589	161,195	565,604

DOMESTIC BAUXITE CONSUMED BY VARIOUS INDUSTRIES
(In long tons)

	Aluminium.	Chemical.	Abrasive.	Total.
1920.....	383,154	85,878	52,276	521,308
1921.....	91,660	41,030	6,860	139,550

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BAUXITE IN FOREIGN COUNTRIES

France.[1]—The French bauxite industry in 1921 witnessed a great diminution in the quarrying of bauxite. Bauxite mining in open pits or quarries is carried on principally in the districts of Var, Bouches-du-Rhone, Herault and Ariege. There are no official figures for production during 1921. The production was very low; from 100,000 to 150,000 tons is a generous total estimate. Shipments to England are said to have fallen below 20,000 tons; shipments to Germany are said to have aggregated between 20,000 and 30,000 tons, while shipments to the United States totaled 8005 tons.

The following figures show the total exports:

	Metric Tons.	Value, Francs.
1919	39,341	1,495,000
1920	130,384	7,171,000
1921	41,327	1,570,000

It is estimated that from 80 to 90 per cent. of the bauxite mined is red bauxite for use in producing alumina. The remaining 10 or 15 per cent. consists of white bauxite of which about one-half is sold to manufacturers of abrasives and one-half is used for the production of sulphate of alumina.

British Guiana.—The imports into the United States from British Guiana for the first five months of 1921 were 10,545 tons. The Demerara Bauxite Co. closed its plants in British Guiana early in 1921. It is reported that extensive investigations were made by British interests with the view of developing large deposits to be mined for the consuming markets.

Dutch Guiana.—The bauxite deposits at Moengo, 160 kilometers from the mouth of the Commewyne River, are under development.

West Africa.[2]—Bauxite deposits were found by A. E. Kitson at Mount Ejuanema. These deposits have been prospected to some extent and an estimate of the tonnage placed at 3,000,000 tons.

Russia.[3]—Bauxite is known to occur from 13 to 40 miles southeast of the town of Tischwin in the Nogorod district. To the north these deposits extend as far as the village of Seglar and west to the edges of the Devonian and coal measures and south to the village of Rudnoya-Gorka. The eastern limits have not yet been defined.

India.—Bauxite is widely distributed in India, but commercial developments have not yet been undertaken.

There was a considerable increase in the production in 1920, from 1682 tons valued at £1934 to 3931.5 tons valued at £4128. The whole

[1] U. S. Dept. of Commerce.
[2] *Mining Mag.*, Mar., 1921.
[3] *Mining Mag.*, Mar. 26, 1921.

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of the output came from Kaira in Bombay. Important bauxite deposits have been recently discovered by Mr. C. S. Middlemiss in the neighborhood of Chakar in the province of Jammu. The quantity available by quarrying at the surface has been estimated at over one million tons, the beds extending uninterruptedly for many miles. Patches of bauxite were also observed by Sir Henry Hayden at Sangar. Analyses of three specimens yielded 79.43, 67.03 and 59.56 per cent. of Al_2O_3 and 1.32, 14.15 and 20.67 per cent. of SiO_2 respectively.[1]

Germany.[2]—Germany's bauxite production before the late war was so insignificant as to render her virtually dependent on French supplies.

Domestic bauxite fields have recently been exploited in Hessen by the Bauxitewerke Aktiengesellschaft at Giessen, which represents the only mine in operation in Germany. The present average monthly output, representing the production of 15 mines employing about 300 men, is 1200 tons. It is planned to bring the production to 20,000 tons during 1922.

Italy.—The Adriatic bauxite deposits were largely developed during the late European war and the output has been purchased mostly by Germany. The deposits are found to the greatest extent in the Dalmatia and Istria districts.

The output during 1921 amounted to 49,100 metric tons, compared with 13,139 tons in 1920.

WORLD'S PRODUCTION OF BAUXITE, IN LONG TONS

Country.	1916.	1917.	1918.	1919.	1920.	1921.
United States	425,100	568,690	605,721	376,566	521,308	139,550
France	104,493	118,973	(a)	160,865	183,735	83,598
United Kingdom	10,329	14,724	9,589	9,221	11,020	(a)
Italy	8,739	7,666	7,676	2,924	12,931	48,322
India	750	1,363	1,192	1,682	3,931	(a)
British Guiana	.....	2,790	4,199	1,967	29,399	.....
Spain	.....	.....	453	1,751	531	.....
Total	549,411	714,206	.....	554,976	762,855	.....

(a) Statistics not available.

Aluminium Salts

Alumina chemicals made from bauxite and other clay to the amount of 184,820 short tons, valued at $7,546,000, were marketed in the United States in 1921. These chemicals were made from 64,380 tons of bauxite and 9830 tons of high-alumina clay, having a total value at the chemical works of $1,028,800.

Six companies report sales of 6280 short tons of ammonia alum at prices per ton ranging from $62 to $82 and averaging $69. Only one

[1] *Rec.* Geol. Surv. of India, 53, 195 (1922).
[2] *Iron Age*, Dec. 15, 1921.

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company made potash alum from bauxite and two made and sold sodium alum.

Most of the alumina made is used in preparing other alumina chemicals, particularily iron-free aluminium sulphate.

Aluminium chloride was made at five plants, from which 5646 short tons was sold at an average price of $98 per ton, though the prices reported ranged from $64 to $442 a ton.

Commercial aluminium sulphate was made at 19 industrial plants and five municipal waterworks in 1921. The sales amounted to 154,920 short tons at prices per ton ranging from $30 to $52 and averaging $36. Municipal water-purification plants made 3060 short tons of "Hoover" alumina sulphate, at an average cost of $17 a ton. It is reported that high-alumina clays are now being used as the crude material for making this chemical, but the percentage of alumina is not given and it is doubtful if anything less than 45 per cent. alumina is being used.

Iron-free aluminium sulphate was made at six plants in 1921 and the total sales amounted to 11,000 short tons at an average price of $54 per ton.

UNITED STATES PRODUCTION AND IMPORTS OF ALUMINIUM SALTS
(In short tons)

Years.	Production.						Imports. (a)	
	Alum.			Aluminium Sulphate.			Quantity.	Value.
	Quantity.	Value.	Per Ton.	Quantity.	Value.	Per Ton.		
1912.....	9,246	$293,995	$31.80	150,427	$2,909,495	$19.34	3,342	$84,606
1913.....	9,605	312,822	32.57	157,749	2,977,708	18.88	2,702	66,549
1914.....	18,238	565,989	31.03	164,954	2,942,572	17.84	2,891	73,028
1915.....	24,915	699,256	28.07	169,153	3,224,495	19.06	1,408	34,320
1916.....	27,257	1,177,881	43.21	153,860	4,410,741	28.67	1,247	68,660
1917.....	19,714	1,017,083	51.60	178,738	5,746,472	32.15	507	39,088
1918.....	20,286	1,051,449	51.83	209,079	6,473,086	30.96	231	18,519
1919.....	17,019	879,198	51.66	200,034	6,763,063	33.80	343	21,877
1920.....	16,824	992,259	58.98	229,888	8,104,457	35.30	1,341	68,999
1921.....	12,220	755,500	61.82	165,920	6,117,200	36.87	1,009	45,973

(a) Includes alumina, aluminium hydrate, or refined bauxite, alum, alum cake, aluminium sulphate aluminous cake, and alum in crystals or ground.

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ANTIMONY

By K. C. Li

The outstanding feature of the antimony situation during 1921 was the record low price recorded. So low did the price of the metal fall that even in China production became unprofitable to most of those engaged in the mining and smelting of antimony ores, and restriction of output was the order of the day. Although official reports covering the production of antimony in all countries have been very slow in coming forth there can be no doubt that practically all of the 1921 production of this metal from newly mined ores came from China, though on a scale very much lower than for many years past. The United States mined no ore and the production of the other principal antimony-mining countries —France, Mexico, Bolivia, etc.,—was insignificant when compared with former years.

Even with the diminished new output supplies were plentiful and the world-wide business depression which promptly followed the post-war inflation which culminated early in 1920 had such an effect on consumption that prices fell away, and at the close of the year were at the lowest levels ever recorded. Imports into the United States were only about 1000 tons less than during 1920 and 4000 tons above the 1919 figures, so that even with heavy buying at the low levels by type-founders and others desiring to protect themselves against possible higher prices for their future requirements, stocks in bonded warehouses were above the average and the invisible supplies at the end of the year were very large.

Prices were fairly steady during the first five months of the year, but in June began to decline to the low record price with which the year closed.

Supplies of war-scrap material, principally shrapnel bullets, were plentiful at very low prices, and these were heavily bought by melters, thus seriously affecting the price of virgin antimony. Although the current year has seen a considerable rise in the price of lead—which has necessarily increased the cost of these bullets—there is still a large tonnage of this old material hanging over the market, besides the regular smelter production of antimonial lead, much of which has been held off the market because producers were unwilling to sell at buyers' prices.

The Market in 1921

The year opened with ordinary brands of Chinese metal, 99 per cent. pure, at 5.20 cts. per lb., silver at 65⅜ cts. per oz. Prices stiffened a

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little just before the Chinese New Year and, as imports during the month were light, the price closed at 5.25 cts., in spite of a decline in silver to 59⅞ cts. February, with very light demand, settled back to a price of 5.20 cts., silver declining still further, closing at 56 cts., after a temporary rise at the beginning of the month to 63⅛ cts. Shipments from China were sparingly offered at about 4½ cts. in bond. Much the same conditions prevailed during March, the demand for spot metal being very light and futures almost neglected. The import price ranged from 4⅜ cts. to 4⅝ cts. in bond, nominal. Silver continued to decline early in the month to 52⅝ cts., but recovered to a high of 58¾ cts. on Mar. 22, closing at 57¼ cts. Even this did not advance the antimony price, which was forced down by heavier arrivals and lack of demand to 5⅛ cts. at the close. April was featured by the heaviest arrivals in many months; but, as these had been mostly sold and moved promptly on discharge from vessels, they had no effect towards depressing prices. Demand became more active as the month drew to its close and the price gained fractionally to 5¼ cts. Silver was also stronger, advancing from an opening price of 56⅛ cts. to a closing of 60⅞ cts. Some business was done in futures late in the month at reported prices of 4⅝ cts. in bond. During May demand was well sustained and better than for some time. Prices advanced to 5½ cts., with considerable interest manifested in futures at from 4½ cts. to 4⅝ cts. in bond. Arrivals were light and well bought. During the second half of the month demand was less and prices closed at 5¼ cts., with futures 4¼ cts. to 4⅜ cts. in bond. Silver opened May at 57¾ cts., rose to 62½ cts. on May 7 and declined to 57½ cts. at the close. June was featured by heavy arrivals and very light demand. Price was steady during the first half of the month, then fell away to a close at 4¾ cts. Futures were neglected, quoted at 4¼ cts. in bond. Silver was steady, opening at 57¾ cts., high at 59⅞ cts., and closing at 59 cts. Business during July was almost at a standstill. Supplies were heavy and increased by arrivals of over 950 tons. Prices declined from the opening high of 4¾ cts. to 4.60 at the close. Futures fell to 4 cts. in bond, despite a rise in silver from an opening price of 58½ cts. to a closing of 61¾ cts. Dullness continued during the entire month of August, with further decline in prices to 4½ cts. duty paid and sales of future-shipment metal as low as 3⅞ cts. in bond. Silver was steady, advancing slightly to 62½ cts. on Aug. 25, closing at 62¼ cts.

Prices having now fallen to unprecedented low levels, consumers began to realize their opportunities, and during September there was a heavy buying movement, assisted by rapidly rising silver prices, which raised the cost of importing metal above the spot levels. Prices advanced rapidly from an opening at 4½ cts. to 5 cts., with futures offered

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at 4½ cts. to 4¾ cts. in bond. Silver rose from 62½ cts. opening to 71⅝ cts. on Sept. 27, closing at 70½ cts. These conditions continued well into October, silver reaching a new high for the year of 73⅝ cts. on Oct. 17, closing at 70¾ cts., and antimony holding well until late in the month, when lack of demand again brought prices down to 4.80 cts. at the close. Sales were made of futures early in the month at prices slightly below the spot equivalent, but rising Chinese exchange put a stop to this, and buyers being temporarily well supplied, November brought only moderate demand, with more selling pressure. Arrivals had continued in regular tonnages so that supplies were large and prices fell off still further to a closing at 4.55 cts. Futures were held at 4⅛ cts. in bond with bids of 4 cts. refused. Silver was easier, opening at 69⅝ cts., rising to 70¼ cts., declining to 66¼ cts., and closing at 67½ cts. December, as usual when business is not active, was very dull. Prices were almost stationary, declining 5 points and closing the year at 4.50 cts. No interest was shown in futures offered from 4¼ cts. down to 4 cts. in bond with bids of 3⅞ cts. refused. Silver also declined from an opening price of 68 cts. to a low on Dec. 8 of 63¼ cts., closing at 64⅝ cts. Both sellers and buyers adopted a waiting policy, preferring to see what would develop with the New Year.

Stocks of antimony in bonded warehouses on Dec. 31 were 1433 tons, compared with 1671 for 1920 and 1073 for 1919. Total imports, reported by the New York Metal Exchange, were 10,606 tons (2240 lb. each) compared with 11,776 tons for 1920, 6692 for 1919, and 11,603 for 1918.

The price of antimony at the close of 1921 was 40 per cent. below the five-year pre-war average. This compares with copper 2½ per cent. below, lead 6⅕ per cent. above, zinc 13⅓ per cent. below, and tin 16⅛ per cent. below.

AVERAGE MONTHLY PRICES OF ANTIMONY (a)

(In cents per pound)

	1916.	1917.	1918.	1919.	1920.	1921.
January	42.45	77.29	14.28	7.43	10.58	5.26
February	44.31	29.80	13.82	7.17	11.59	5.25
March	44.75	32.89	13.09	6.80	11.06	5.28
April	42.06	34.04	12.54	6.79	10.50	5.14
May	31.60	25.20	12.85	7.66	9.66	5.25
June	20.05	19.51	13.06	8.44	8.29	5.09
July	14.70	15.83	13.20	8.99	7.50	4.73
August	11.53	15.06	14.00	8.96	7.18	4.60
September	11.81	14.94	14.15	8.63	7.11	4.56
October	12.70	14.75	13.32	8.71	6.72	5.09
November	13.84	13.91	8.77	9.11	6.11	4.73
December	14.59	15.06	7.92	9.62	5.53	4.50
Year	25.37	20.69	12.58	8.19	8.49	4.96

(a) *Eng. Min. Jour.* quotations, ordinaries.

It can be seen from these figures how greatly the production of antimony was over-stimulated by the tremendous war demand, since the prices of 1921, which have continued into the current year, touching even

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lower levels during the first quarter of 1922, may be entirely attributed to over-supplies and the appearance of war scrap in the market. The consumption of the metal in the United States is now fully up to normal and is rapidly recovering in Europe.

IMPORTS

Imports of matte, regulus, and metal into the United States in 1921 amounted to 21,153,331 lb. valued at $697,121, against 24,947,121 lb. valued at $1,475,276 in 1920 and 14,250,158 lb. valued at $870,767 in 1919.

Imports of antimony ore were only 190 tons valued at $11,682 in 1921, compared with 1526 tons valued at $70,285 in 1920 and 885 tons valued at $49,527 in 1919.

TARIFF

During 1921 there was at several different times considerable talk about tariff action and its effect on antimony prices.

Early in March it was feared that an emergency bill might cover certain of the metals. For a few days prices were affected, but as it became evident that no action would be taken before 1922 the agitation died away.

At present what action will be taken and when seems as uncertain as ever, with resulting unsettled conditions in those commodities where appreciable changes in rates are anticipated.

Under the present act antimony regulus, or metal, pays an import duty of 10 per cent. *ad valorem*, as does needle antimony, the crude liquated sulphide. The bill reported to the House of Representatives carried 1½ cts. per lb. on metal and proposed to place crude on the free list. As the very evident effect of such action would be to substitute expensive smelting and refining in the United States of Chinese crude, imported free of duty, for the cheap smelting and refining now done in China, thus at one and the same time preventing our Government from deriving any revenue from antimony imports and increasing the cost of the metal to the American consumer, the Senate Bill proposes that crude shall pay a duty of ¾ ct. per lb., while regulus pays 2 cts. per lb. Ore remains, as at present, on the free list, so that American smelting works and producers of antimony products may purchase their raw material free of duty and enjoy protection to their industries. Antimony oxide, now produced in considerable quantity in the United States, which pays at present 15 per cent. *ad valorem* duty (through an error in punctuating the present bill, the duty intended having been 25 per cent.), will pay, should the proposed Act be adopted, 1½ cts. per lb. plus 25 per cent.

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As no serious opposition has appeared to these proposed changes it seems likely they will be adopted. In the meantime, as in the case of other commodities, conditions are unsettled, pending the passing of the Act, and dealings in future deliveries are very difficult.

PRODUCTION

Since the war the United States has mined no antimony ore, nor is any likely to be mined unless the metal should advance greatly in price. Practically all of the metal coming out of the ground today comes from China, except for the antimony which is contained in smelter production of antimonial lead. Production figures under these conditions are most difficult to obtain and official figures for 1921 are more backward than usual in appearing in printed form. Chinese statistics are always difficult to obtain and recent unsettled conditions in that country have so added to this difficulty that nothing reliable and accurate is available. It is known that production is greatly curtailed and should war stocks of old material finally disappear and world demand for the virgin metal return to normal or pre-war figures, some difficulty may be anticipated in rapidly increasing production again and prices will certainly advance. Even now

ANTIMONY ORE PRODUCED IN THE UNITED STATES (a)
(In short tons)

Year.	Ore.	Metal Content.
1915	5000	2100
1916	4500	1770
1917	1060	390
1918	190	50
1919	*Nil.*	*Nil.*
1920	*Nil.*	*Nil.*
1921	*Nil.*	*Nil.*

(a) U. S. Geol. Surv. Production negligible prior to 1915.

ANTIMONY STATISTICS OF THE UNITED STATES
(In tons of 2000 lb.)

Year	Imports, Antimony Content.			Production. (a)			
					In Hard Lead.		
	Metal or Regulus.	Crude and Ore.	Type Metal.	From Domestic Ore.	From Domestic Ore.	From Imported Ore.	Recovered from Old Alloys, Scrap, Dross, etc.
1910	4,950	*Nil.*	1,109	.....	1,598	631	2,779
1911	5,479	*Nil.*	727	.....	1,543	711	2,369
1912	6,969	*Nil.*	52	.....	1,224	725	2,506
1913	7,667	25	50	.....	2,204	304	2,705
1914	6,535	993	94	.....	2,518	175	2,646
1915	8,742	1,682	172	.....	2,961	464	3,102
1916	9,875	(b)4,742	119	.....	3,496(d)	.....	4,480
1917	17,825	(b)5,960	*Nil.*	258	2,759(d)	2,182(c)	4,961
1918	13,874	(b)1,360	19	127	2,566(d)	2,490(c)	5,226
1919	7,125	(b)364	1,197	*Nil*	1,943(d)	.....	4,399
1920	12,474	(b)682	2,063	*Nil*	2,033(d)	.....	5,600
1921	10,577	(b)98	4,132	*Nil*	1,589(d)	.....	.....

(a) Metallic antimony; figures of U. S. Geological Survey; 1919 figures from *Metal Statistics*. (b) In ore only. (c) Antimony metal. (d) Includes both domestic and foreign ore.

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consumption in the United States is fairly large and, although imports from China continue in fair volume, stocks do not seem to be increasing and sales are in good volume. Statistically the position of the metal has unquestionably improved greatly during 1921 and with continued revival in those industries consuming antimony, the outlook for the metal should be much better.

Data from Foreign Countries

Algeria exported 310 metric tons of antimony ore in 1921, compared with 2966 tons in 1920 and 2160 tons in 1919.

Australia exported 380 long tons of antimony ore in 1921. In Queensland an antimony lode was discovered near Cooktown, but owing to the very low price of the metal it has not been worked. There has been no production of ore in Queensland since 1919, and then only a very small amount.

Antimony exports from China are given in the following table,[1] in long tons:

Year.	Ore.	Regulus.	Crude.
1918	472	14,154	1,678
1919	570	6,110	2,161
1920	1,330	9,572	4,486

No data have yet been issued for 1921. Of the 14,058 tons of regulus and crude exported in 1920, 8992 tons went to the United States, 2945 to England, and 2121 tons to other countries. The value of the exports of regulus and crude was $1,304,404 in 1920, compared with $836,326 in 1919.

A similar table from the *Metal Bulletin* gives the imports and exports of France, in metric tons:

Year.	Ore.	Regulus.	Crude.
IMPORTS			
1919	1,866	9	100
1920	4,236	607	368
1921	6	214	98
EXPORTS			
1919	162	229	400
1920	944	583	620
1921	940	191	198

Nearly all of the antimony exported from Japan originates in China. This is illustrated by the following figures of Japanese imports and exports of antimony, in metric tons, covering the first 10 months of each year:

Year.	Imports.	Exports.
1919	4,437	973
1920	4,782	903
1921	4,834	127

Mexico reports a production of 45 metric tons of antimony in 1921, 623 tons in 1920, and 471 tons in 1919.

[1] *Metal Bull.*

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WORLD'S PRODUCTION OF ANTIMONY (a)
(In metric tons)

Country.	1913.	1914.	1915.	1916.	1917.	1918.	1919.	1920.
United States	.....	.....	1,760	1,420	310	45	*Nil.*	*Nil.*
Canada	.....	.....	381	272	87	.....	40	*Nil.*
Mexico	2,340	1,570	(b)200	829	2,647	3,269	471	623
Bolivia	30	102	9,359	15,077	12,860	4,770	(c)130	9
Peru	.....	.....	260	930	450	160	33	.....
Hungary	1,038	.....	.....	.....	444	.....	.....	.....
Austria-Hungary	840	.....	.....	.....	.....	.....	.....	.....
Germany	.....	.....	(b)700	.....	.....	.....	.....	644
France	5,170	540	893	2,430	2,354	1,329	976	234
Italy	360	138	720	4,334	960	516	13	80
Spain	.....	.....	100	170	160	(b)20	*Nil.*	.....
Portugal	10	.....	.....	(b)1,000	.....	.....	.....	.....
Serbia	(b)250	.....	.....	.....	725	.....	.....	(c)831
Algeria	186	320	2,740	8,940	4,550	2,218	605	830
British South Africa	30	.....	50	380	300	99	32	.....
China	13,032	19,647	23,357	42,800	31,000	(b)18,112	8,923	(c)15,998
Japan	20	32	180	280	8	41	.....	.....
India	.....	.....	.....	400	50	*Nil.*	3	*Nil.*
Indo-China	.....	.....	160	642	101	.....	.....	.....
Borneo	.....	300	120	.....	.....	.....	.....	.....
Asia Minor	240	.....	.....	.....	.....	.....	.....	.....
Victoria	960	890	1,300	1,320	(b)600	576	580	480
New South Wales	10	20	320	310	150	(b)120	(b)30	64
Queensland	.....	.....	80	80	.....	.....	3	*Nil.*
Western Australia	.....	.....	.....	20	10	.....	*Nil.*	*Nil.*
	24,516	23,559	43,180	81,634	57,766	31,275	11,839	18,819

(a) U. S. Geol. Surv., with additions from official reports. (b) Incomplete data; actual production probably larger. (c) Exports.

TECHNOLOGY

There is little to add to what was reported last year in MINERAL INDUSTRY for 1920.

Good reports are heard of the success of antimony-oxide pigment, and experimental work continues to be carried on by the rubber trade looking towards the substitution of antimony oxide for zinc oxide in the production of certain grades of rubber, both for rubber tires and other purposes. No other new uses have been reported. The outstanding fact is, however, that greater quantities of the metal are constantly finding their way into consumption in one form or another, no doubt stimulated by the low selling prices of the last two years. It would be strange indeed if new uses did not appear for a metal with the valuable and unique properties possessed by antimony now selling in the world's markets at such very low cost.

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ARSENIC

By Arthur E. Wells

Production in the United States.—There are five plants in the United States with equipment for producing crude and refined white arsenic (arsenic trioxide), *viz.:*

1. The Globe Smelter of the American Smelting and Refining Co., near Denver, Colo.

2. The Tacoma Smelter of the American Smelting and Refining Co., at Tacoma, Wash.

3. The Perth Amboy, N. J., plant of the American Smelting and Refining Co.

4. The Washoe plant, at Anaconda, Mont., of the Anaconda Copper Mining Co.

5. The Midvale, Utah, plant of the United States Smelting, Refining and Mining Co.

These five plants have a total estimated capacity of 18,000 tons of crude and white arsenic annually, but this capacity probably will not be reached unless ores are purchased specially for their content of arsenic.

Arsenic is produced almost entirely as a by-product, the precious and semi-precious metals being the direct products. The cost of production of white arsenic in the smelting plant is to a large extent a matter of bookkeeping, in that the cost of the crude arsenic up until the time it is collected from the smelter flues is, strictly speaking, an essential step in the smelting operation.

After the arsenical fumes and dust are collected in the flues, bag-houses, or in the Cottrell electrical precipitation apparatus, they are refined in special furnaces or reverberatories. The refining costs have been low, although transportation charges on material shipped a considerable distance from the smelters have added to the total cost of production.

The direct production of white arsenic has been attempted a number of times in this country, based on the refining of arsenopyrite, containing no other element of value except iron, of which there are deposits scattered all over the American Continent. It is easily possible from a technical standpoint to produce 99-per cent. arsenic from arsenopyrite, but the plant installation and the process are both costly, and in the face of the violent fluctuations of market prices and by-product competition, little real progress in this branch of the industry has ever been made.

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The United States Smelting, Refining & Mining Co. has organized at Midvale, Utah, a new department to manufacture insecticides, fungicides and weed-killers, using arsenic in various combinations.

During 1921 the Midvale plant of the United States Smelting, Refining & Mining Co. was the largest producer of white arsenic, the greater part of that production being made directly into fungicide.

Very little white arsenic was produced at the Globe, Perth Amboy, or Anaconda plants, and the production of high-grade white arsenic at Tacoma was below normal.

The total production from all the plants in 1921 was approximately 5732 short tons of crude and refined white arsenic, as compared with 11,502 tons in 1920.[1]

The production over a period of years is given below:

STATISTICS OF ARSENIC IN THE UNITED STATES (a)
(Short Tons)

Year.	White Arsenic.							Sulphide of Arsenic.		
	Production.		Imports.		Supply.			Imports.		
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Per Ton.	Tons.	Value.	Per Ton.
1907	1,751	$163,000	203	$21,558	1,954	$184,558	$94.47	4,961	$553,440	$88.61
1908	1,302	99,193	168	13,263	1,470	112,456	76.46	4,796	417,137	86.97
1909	1,214	52,946	444	31,235	1,638	84,181	51.39	3,592	272,493	75.86
1910	1,497	52,305	1,010	62,590	2,507	114,895	45.83	4,128	251,716	60.97
1911	3,132	73,408	1,921	116,948	5,053	190,356	37.68	2,702	159,626	59.04
1912	3,141	190,757	3,103	200,616	6,244	391,373	62.68	3,379	246,815	73.04
1913	2,513	159,236	1,519	133,597	4,032	292,833	72.62	3,344	285,537	85.38
1914	4,670	313,147	1,594	109,121	6,244	422,268	67.42	2,040	165,266	81.03
1915	5,498	302,116	1,400	113,677	6,898	415,793	60.28	1,787	154,517	86.46
1916	5,986	555,187	1,071	107,876	7,057	663,063	93.96	1,090	124,844	114.49
1917	6,151	1,118,313	1,178	264,534	7,329	1,382,847	188.50	2,776	410,341	147.80
1918	6,323	1,213,000	1,847	441,212	8,170	1,654,212	202.47	5,651	998,011	176.61
1919	6,029	1,180,000	4,389	624,494	10,418	1,804,494	174.17	2,151	316,687	147.22
1920	11,502	2,021,356	3,740	532,635	15,242	2,553,991	167.95	4,080	684,016	167.65
1921	5,732	.....	1,669	253,250	7,401	.....	.....	3,343	531,322	158.93

(a) Production from U. S. Geol. Surv.; imports from Dept. of Commerce.

Market Price for White Arsenic.—The market price of white arsenic has fluctuated in the last 15 years between 1½ cts. and 20 cts. per lb., the low level having been touched in the pre-war period and the high mark at different times within the last few years. The wide fluctuations were, of course, partially due to war conditions, but these conditions were intensified by the various irregular factors which always have and always will affect this product.

During the war the Government finally stepped in and fixed the selling price by the producers at 9 cts. per lb., allocating the available tonnage to the various industries according to their importance from a "win the

[1] *Eng. Min. Jour.*, Jan. 21, 1922.

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war" standpoint. Since then the extreme demand was reached in 1920 when the open-market price stayed around 15 cts. for several months for immediate delivery of carload quantities. With the sudden decline of prices for all raw materials and finished products in the latter part of 1920, arsenic went down swiftly with the rest, and some contracts were made between 5 and 6 cts. per lb. in the last quarter of 1921.

The railroad freight-rate on crude or white arsenic from Denver to New York, or points east of the Ohio-Pennsylvania state line, at the end of 1920 was $18.86 a ton in barrels or casks for a minimum of 50,000 lb.; the rate from Salt Lake City was $20.00, and from Seattle and Tacoma $25.00.

Uses for White Arsenic.—For many years arsenic has been used at glass works, in making arsenical sprays, cattle and sheep dip, and for hide preservatives. During the last several years there has been a great increase in the use for weed-killers and for insecticides, especially as calcium arsenate.

With the wider dissemination of technical advice to the farmers, the merrkacalcium arsenate promises to increase with great rapidity. The use of able development of the use for this material has been retarded by the financial trouble of the South in 1921, but with a return to more nearly normal financial conditions, the demand for calcium arsenate in the Southern cotton fields will undoubtedly increase tremendously in the next few years.

Taking the figures for 1920 as a basis of estimate, it appears that the normal consumption of arsenic in this country for all purposes may be about 16,000 tons per year.

It is not evident how this requirement shall be met. At the present time it would seem that with the operations of the smelters curtailed and the arsenic content of the ores in general decreasing, the supplies of by-product arsenic will be less in the immediate future than they have been in the past. However, it is rather difficult to predict the potential domestic supply, as one company alone, the Anaconda Copper Mining Co., under normal operations, could produce half the country's requirements.

As the demand for arsenical products is world-wide and the use of spray materials is increasing in all agricultural countries, it is not likely that a large tonnage of imported arsenic will find its way to the American market unless the price-level is held relatively high.

The arsenic producers of Mexico and Canada are the chief competitors in the arsenic industry of the United States, and under normal operations would be able to supply the market with a considerable tonnage of cheap arsenic.

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WORLD'S PRODUCTION OF ARSENIC
(In metric tons)

Year.	Canada. (a)	Germany. (b)	Italy. (d)	Japan. (a)	Portugal. (d)	Spain. (b)	United Kingdom. (a)	United States. (a)	France. (d)
1906	*Nil.*	3,052	.....	5	1,322	1,114	1,625	754	6,534
1907	317	2,904	73	7	1,538	2,400	1,523	916	7,900
1908	649	2,822	451	20	1,655	2,004	2,007	1,301	2,361
1909	1,020	2,911	*Nil.*	8	1,420	506	2,911	914	2,141
1910	1,363	3,066	*Nil.*	12	974	444	2,187	1,203	8,045
1911	1,815	2,981	16	6	887	331	2,178	2,800	19,000
1912	1,858	4,869	*Nil.*	.....	1,006	(c)	2,228	2,855	81,880
1913	1,538	5,008	*Nil.*	.....	925	.....	1,723	2,158	70,613
1914	1,576	4,700	*Nil.*	.....	960	.....	2,020	4,238	250
1915	2,174	4,100	*Nil.*	15	.....	.....	2,536	4,990	1,300
1916	1,983	3,622	*Nil.*	(c)	.....	.....	2,587	5,430	1,800
1917	(c)2,663	5,554	*Nil.*	(c)	.....	.....	2,669	5,580	344
1918	(c)3,233	10,555	*Nil.*	398	.....	104	2,387	5,737	728
1919	(c)3,074	5,116	*Nil.*	1,299	.....	42	2,568	5,470	2,261
1920	(c)2,231	.....	*Nil.*	.....	.....	.....	2,029	10,435	523
1921	(c)1,356	.....	*Nil.*	.....	.....	.....	.....	5,200	.....

(a) White arsenic. (b) Oxide, sulphide, etc. (c) Not yet available. (d) Ore. (e) Includes arsenic in ore.

Arsenic in Foreign Countries

Canada.—The principal source of arsenic in Canada is the cobalt-nickel ore of the Cobalt district.

Arsenic was first reported as a constituent of ores mined at Cobalt in 1904, when the mines were first opened up. In the southern part of Ontario there are now four reduction plants operating on silver ores and concentrates from Cobalt. At the Deloro works, arsenical fume is collected in bag-houses and then refined in coke-fired reverberatory furnaces.

PRODUCTION AND EXPORTS OF CANADIAN WHITE ARSENIC

Year.	Production. (a)		Exports. (b)	
	Short Tons.	Value.	Short Tons.	Value.
1913	1,692	$101,463	1,303	$107,094
1914	1,737	104,015	1,876	132,567
1915	2,396	147,830	2,318	174,190
1916	2,186	262,340	1,975	197,458
1917	2,936	669,431	4,286	507,898
1918	3,560	563,639	2,672	393,883
1919	3,389	509,924	2,506	355,654
1920	2,459	447,848	1,028	237,267
1921	1,491	269,300	.....	.....

(a) Includes some arsenic in concentrates. Figures of the Dominion Bureau of Statistics. (b) Practically all was exported to the United States.

Japan.—The smelting concerns in Japan treating copper and lead ores have been compelled by the agricultural interests to adopt methods to recover the arsenic. Eight Cottrell electrical precipitation plants were installed in 1918 and 1919, and considerable quantities of high-grade arsenical fume recovered.

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The most recent available statistics give a total production of white arsenic of 440 short tons in 1918 and 1430 tons in 1919. It is claimed that about 4000 tons might be produced annually from known sources.

Mexico.—The most important producer of white arsenic in Mexico is the Mapimi smelter, operated by the Compania Minera de Pinoles, and owned by the American Metal Co., Ltd. This plant is rated to produce, under normal conditions, about 5000 tons of white arsenic per year. The production in 1920 was only about 1000 tons. The plant was closed down in 1921.

The Mexican Government statistics give a production of 2092 metric tons of arsenic in 1920, and 785 tons in 1921.

Great Britain.—The arsenical ores of Great Britain are found chiefly in Devon and Cornwall. During the war arsenic refineries were constructed by the two mining companies at South Crofty and East Pool, Cornwall, and many of the mines in Cornwall and Devon are now producing arsenic.

PRODUCTION OF ARSENIC IN THE UNITED KINGDOM

Year.	Arsenical Pyrite.		White Arsenic.	
	Long Tons.	Value.	Long Tons.	Value.
1913	35	£29	1,695	£16,616
1914	.....	.....	1,988	19,052
1915	421	233	2,496	32,779
1916	300	300	2,545	56,104
1917	434	2,599	2,626	146,031
1918	477	4,380	2,349	210,101
1919	75	.....	2,527	.....
1920	1,178	.....	1,997	.....

Australia.—Within the Commonwealth there are now several works established for the manufacture of white arsenic from arsenopyrite, a modern plant having been put into operation at Jibbinbar, in Queensland. Arsenic is being produced at Jibbinbar by the State, the ore being a straight arsenopyrite containing no other valuable metals. The furnace at Jibbinbar was in commission in 1921 from the beginning of the year until the end of July, when the operations of the treatment plant ceased in consequence of overproduction. The arsenic mined in 1921 amounted to 220 long tons valued at £12,325, against 305 tons valued at £16,760 in 1920. The upper part of the Sundown mine, near Ballandean, proved much richer in arsenic than had been thought.[1]

Germany.—The lead works at Freiberg produce white arsenic and the sulphides, realgar and orpiment, the ores being brought from mining areas away from this center.

[1] *Queens. Gov. Min. Jour.*, July 15, 1921, April 15, 1922.

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Austria.—The sulphide, realgar, is produced as a by-product in the distillation of mercury.

Portugal.—Some arsenic is produced in Portugal, derived primarily from arsenical ores.

China.—Arsenic is produced from an ore containing about 15 per cent. arsenic as arsenopyrite. The ore is broken to 5-in. size and roasted in a furnace built of granite boulders or any other rock that is handy. Like all Chinese metallurgical work, the method is simple, cheap and inefficient.[1]

Arsenic is in demand in China for packing the tombs of the richer class.

[1] *Eng. Min. Jour.*, Oct. 29, 1921.

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ASBESTOS[1]

By Oliver Bowles

The chief asbestos deposits of the world are in Canada, while other important deposits are found in Russia, South Africa, and Arizona. Deposits at present of minor importance, but some of which may develop greatly in the future, occur in Italy, Cyprus, China, and Australia.

Market Conditions.—The asbestos industry along with many others has experienced during 1921 what is probably the worst year in its recent history. The depression in all industries using asbestos has been reflected in a very small demand for all classes of fibers, and in consequence the entire industry has been stagnant. The abnormally high prices of a year ago have dropped greatly; No. 1 crude, which in December, 1920, was quoted beyond $3000 per ton, dropped to between $1000 and $1500 per ton in December, 1921, and other grades dropped accordingly. Some of the mines both in the United States and Canada have been operating part time only, while others have been shut down entirely. While Canadian production dropped to barely two-thirds of that for 1920, stocks in warehouses increased 30,000 tons, a condition indicative of the great decrease in demand. The African industry seems to have been sustained somewhat better than that in America. Fluctuations in prices of the various grades of asbestos during 1920 and 1921 are shown in the accompanying chart prepared by Edward Sampson of the United States Geological Survey.

General Production Situation.—Taking into account the increased stocks on hand Canadian production dropped over 60,000 tons during 1921. Production of crudes amounted to about 2975 tons, of which 2032 tons was still in warehouses at the end of the year.

United States production, which is confined almost entirely to Arizona, was approximately half as much as during the previous year, most of the mines being inactive.

A remarkable feature of the situation is that Rhodesian production increased from 18,823 tons in 1920 to 19,528 tons in 1921. In the Union of South Africa production dropped from 7112 tons in 1920 to 5122 tons in 1921.

Russia, which has for several years been a closed book in so far as asbestos figures are concerned, again appears in statistical reports with a production during 1920 of over 2600 metric tons.

[1] Published by permission of the Director of the Bureau of Mines.

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With the exception of Rhodesia, production in all countries has been remarkably low during the year.

Imports and Exports of Asbestos.—As a very large proportion of the United States requirements are imported, the various sources from which

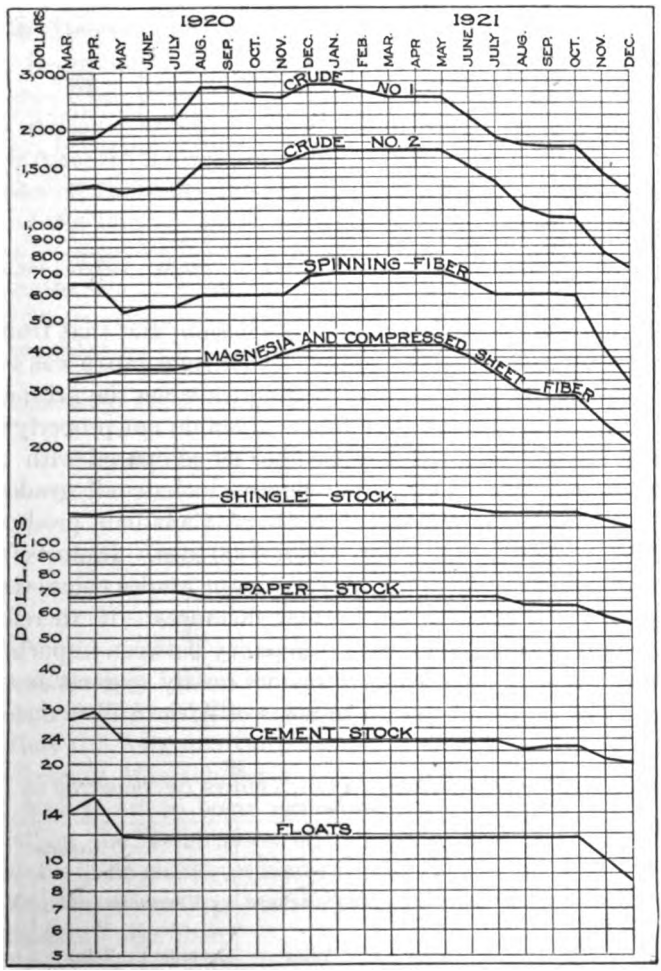

FIG. 1.—Asbestos prices in 1920 and 1921.

imports are obtained may be of interest to the consumer. The following table compiled by Edward Sampson of the U. S. Geological Survey shows the imports in short tons over a series of years.

The actual source of the asbestos in some instances is not indicated by such a table. The asbestos from England is South African, that from France is probably Cape blue, that from Germany was probably Russian

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UNITED STATES IMPORTS OF ASBESTOS
(In short tons)

Source.	1914.	1915.	1916.	1917.	1918.	1919.	1920.	1921.
Australia	.....	.....	.....	.....	.....	.....	3	1
British India	.....	.....	.....	.....	.....	1	.....	.....
British South Africa	.....	.....	112	1,791	837	900	2,233	504
Canada	71,781	93,565	114,978	131,525	134,813	133,662	162,717	71,412
China	.....	.....	.....	.....	.....	1	17	50
Colombia	.....	.....	.....	.....	1	.....	.....	.....
England	.....	.....	1,072	296	.....	156	746	200
France	.....	.....	.....	.....	.....	450	.....	.....
Germany	11	1	.....	.....	.....	.....	.....	11
Hongkong	.....	.....	.....	.....	.....	.....	.....	1
Greece	.....	.....	.....	.....	.....	.....	81	.....
Italy	2	.....	.....	.....	.....	.....	3	2
Japan	.....	.....	.....	.....	.....	.....	100	1
Portuguese Africa	.....	.....	.....	496	2,049	100	1,584	279
Russia in Europe	72	.....	.....	.....	.....	.....	.....	.....
Trinidad and Tobago	.....	.....	.....	.....	.....	.....	.....	1
Turkey in Asia	.....	.....	.....	.....	.....	.....	74	.....
Total	71,866	93,566	116,162	134,108	137,700	135,270	167,558	72,462

fiber, from Portuguese Africa, chiefly Rhodesian, and that from Turkey and Greece was probably from Cyprus. That from Japan was a shipment of Canadian and African fiber sent to America when the price advanced.

It is to be noted also that the figures given do not properly represent the relative importance of Canadian fiber as compared with that from other foreign countries. Canadian figures include all grades of mill fiber, which constitute the great bulk of Canadian production, the imports of spinning fiber being only about 6000 tons. Imports from other countries are chiefly of spinning fiber, as lower grades command too low a price to justify transportation for long distances. If, therefore, high-grade fiber only is considered, the discrepancy between imports of Canadian fiber and that of other countries is not nearly so great as appears in the table. The great increase in imports of African fiber during recent years is noteworthy.

UNITED STATES IMPORTS AND EXPORTS OF ASBESTOS (a)
(In long tons)

Year.	Imports.			Exports.		
	Unmanufactured.		Manufactured.	Unmanufactured.		Manufactured.
	Quantity.	Value.	Value.	Quantity.	Value.	Value.
1912	63,860	$1,456,012	$363,759	.....	.....	$601,701
1913	86,737	1,928,705	389,664	.....	.....	754,102
1914	64,166	1,407,758	368,344	.....	.....	513,037
1915	83,541	1,981,483	137,320	.....	.....	764,050
1916	103,716	3,303,470	135,064	279	$6,133	1,209,076
1917	119,739	4,521,172	65,096	632	116,580	1,932,551
1918	122,946	6,337,585	27,476	622	51,053	2,493,325
1919	120,777	7,369,685	257,381	999	157,416	3,529,348
1920	149,605	9,120,253	619,054	549	141,071	4,431,132
1921	64,698	2,918,302	379,858	464	101,616	2,606,426

(a) Bureau of Foreign and Domestic Commerce.

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The preceding table gives the quantity in long tons and value of imports and exports over a series of years.

Domestic Production.—The great bulk of spinning fiber produced in the United States is obtained in Arizona, though small quantities are mined in California and Wyoming. Asbestos suitable for filter purposes is obtained in Maryland. Amphibole asbestos used in fireproofing and insulation is obtained in Georgia, North Carolina, California, and Washington. The Arizona industry was almost at a standstill during 1921, the Arizona Asbestos Association being the largest producer.

There is prospect of increased activity in asbestos mining in California. Two companies, the California Asbestos Mining Co. in San Bernardino County and the Pacific Asbestos Corporation in Calaveras County, are said to be erecting mills, but produced no fiber during 1921. The Sierra Asbestos Co. in Nevada County maintained a small production.

United States production over a series of years is shown in the following table compiled by the U. S. Geological Survey.

DOMESTIC ASBESTOS MARKETED IN THE UNITED STATES

Year.	Quantity, Short Tons.	Value.	Average Selling Price per Ton.
1914	1,247	$18,965	$15.21
1915	1,731	76,952	44.46
1916	1,479	448,214	303.05
1917	1,683	506,056	300.69
1918	1,002	124,687	124.44
1919	1,161	243,265	213.84
1920	1,648	650,311	394.61
1921	831	336,968	405.50

It is noteworthy that Vermont, from which no asbestos has been obtained since 1912, is likely again to become a producer. It was reported that the Asbestos Corporation of America, recently chartered under the laws of Massachusetts to operate asbestos mines and mills in Vermont, was about to begin operations early in 1922. The quarries are located on the well-known fiber-bearing deposit near Hyde Park. The product will be chiefly mill-stock grades. Recent exploration work indicates that there is a large reserve of ore similar in grade and character to the Canadian "slip fiber."

The United States Geological Survey received reports of production from the following operators during 1921.

Arizona Asbestos Association, N. A. Nelson, Supt., Globe, Ariz.
Regal Mine (E. Schaaf Regelman), Globe, Ariz.
Globe Asbestos Co. (A. E. Minium), Globe, Ariz.
Alene Asbestos Association (E. Pierce), Young, Ariz.
American Ores & Asbestos Co., A. B. Shutts, Mgr., Globe, Ariz.
Penn Asbestos Mines Co., Dr. Huber, Pres., North Wales, Pa.

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H. P. Wightman & Pierce, Globe, Ariz.
Shanley and Morrison, Globe, Ariz.
C. A. Watkins, Box 194, Globe, Ariz.
Sierra Asbestos Co., 704 Union Savings Bldg., Oakland, Calif.
Sall Mountain Co., 203 S. La Salle St., Chicago, Ill.
Powhatan Mining Co., Woodlawn, Baltimore, Md.
Western Mineral Co., Kamiah, Idaho.

Foreign Countries

Canada.—While the production of asbestos in the Province of Quebec reached a record figure in 1920, the following year witnessed a serious decline. Not including asbestic, shipments and sales during 1921 were only about 48 per cent. in tonnage and 35 per cent. in value of those in 1920.

Canadian production in 1921 is shown in the following table, in short tons.

PRODUCTION OF ASBESTOS IN THE PROVINCE OF QUEBEC FOR 1921

Designation of Grade.	Shipments and Sales. Tons.	Value.	Average Value per Ton.	Stock on Hand Dec. 31, 1921. Tons.	Value.
Crude No. 1	183	$234,482	$1,281.32	857	$965,837
Crude No. 2	760	339,649	446.91	2,475	1,710,163
Spinning fiber	5,372	1,413,318	263.09	7,646	2,124,801
Shingle fiber	9,650	981,872	101.75	5,324	524,490
Paper stocks and others	71,509	2,230,468	31.19	37,043	1,368,057
Totals	87,474	$5,199,789	$59.44	53,345	$6,693,348
Asbestic	12,397	14,536	1.17	3	4
Totals	99,871	$5,214,325	.....	53,348	$6,693,352

Quantity of rock mined during the year, 2,191,377 tons.

Some plants have shut down entirely, and most of the others have greatly curtailed their operations. By the end of June most mines were working one shift only for 5 days in the week. In December, however, the Asbestos Corporation of Canada, the largest producer, had greatly increased its production over that of the summer months. An effort has been made by most companies to retain their operating staffs as complete as possible so as to be prepared for renewal of activity. Considerable exploration and development work has been accomplished during the period of depression. During May wages were reduced from 42½ to 32½ cts. an hour. Several properties have changed hands, and a number of mills have been remodeled. There seems to be no foundation for the recurring rumors of proposed provincial legislation to compel the manufacture of asbestos in Canada.

A notable feature of the industry is the marked increase in manufacture of asbestos goods in Canada. Prior to 1921 one company only,

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the Asbestos Manufacturing Co., Ltd., manufactured asbestos products in Quebec. This company produced asbestos paper, shingles, pipe-covering, etc. Early in 1921 a second operator, Jos. Poulin at East Broughton, began the manufacturing of asbestos brakeband linings, which were sold under the trade name of "Asbestonos." The Canadian Johns-Manville Co. is also constructing a well-equipped plant at Asbestos near Danville for the manufacture of its well-known products. In Ontario one plant is in operation and two others are carrying on experimental work in the manufacture of asbestos products.

OUTPUT, SALES, AND STOCK OF ASBESTOS IN CANADA (a)

	1919.		1920.		1921.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
Output:						
Crude	4,065	.....	4,098	.....	3,082	.....
Mill stock	153,507	.....	165,348	.....	120,627	.....
Sales:						
Crude	3,928	$3,214,002	3,894	$3,811,762	898	$632,839
Mill stock	132,837	7,695,430	174,723	10,922,837	65,425	4,052,730
Asbestic	22,471	65,917	20,956	57,602	24,084	121,483
Stocks on hand, Dec. 31:						
Crude	1,338	974,260	1,295	1,443,583	3,747	.....
Mill stock	31,110	1,952,629	22,114	1,650,981	41,015	.....

(a) Summary Rept., Min. Prod. of Canada, Can. Dept. of Mines; latest year from Prelim. Rept.

It may be noted that there are slight discrepancies in the figures given by the Department of Mines at Ottawa, from those given in the table on page 50, supplied by the Bureau of Mines of the Province of Quebec, but the differences are not great enough to affect materially the general situation.

Union of South Africa.—Total production of asbestos in the Union of South Africa during 1921 was 5122 tons valued at £103,067, as compared with 7112 tons valued at £114,195 in 1920.

Some important recent developments are to be noted in Transvaal. In September, 1920, a new company, the South African Asbestos Mines, Ltd., was incorporated to operate mines in the Pietersburg district close to the Olifants River. The 65-mile wagon-haul to the nearest railroad is the most serious problem confronting the new company. In July, 1921, production had reached 30 tons of blue asbestos per month, and at that time it commanded a price of £30 per ton. A greatly increased production is expected when the plant is completed.

A. L. Hall of the Geological Survey of South Africa has described a remarkable deposit of chrysotile near Barberton in southeastern Transvaal. As a high percentage of fiber is available and the location not far from an ocean port, this deposit has great possibilities.

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The system of grading South African asbestos as given in the following table may be of interest to American consumers.

Grades of South African Asbestos

"S," up to and including fiber 5/16 in. long
"A," from 3/8 to 3/4 in. long
"B," from 3/4 to 1 1/4 in. long
"C," from 1 1/4 to 2 in. long
"D," over 2 in. long
"DA," discolored fiber up to 3/4 in.
"DB," discolored fiber longer than 3/4 in.

Rhodesia.—Rhodesian fiber is a high grade of chrysotile obtained in the Bulawayo and Victoria districts. While considerable Rhodesian fiber is shipped to America there is also a large demand from England and Japan. The total production for 1921 as given by the Rhodesian Chamber of Commerce was 19,528 long tons valued at £795,698. Rhodesian production over a number of years is shown in the following table:

Year.	Long Tons.	Value.
1913	290	£5,224
1914	487	8,612
1915	2,010	32,190
1916	6,157	99,059
1917	9,562	189,890
1918	8,574	158,684
1919	9,798	425,240
1920	18,823	459,572
1921	19,528	795,698

Rhodesia is the only producing district that shows an increase in production in 1921 over that of 1920. The strong European demand for this fiber is evidently due to the low price, which permits competition with the higher grades of Canadian mill-fiber.

Other Foreign Countries.—At the beginning of the European war Russia stood next to Canada as a producer of asbestos. The maximum production was in 1913, when it reached 19,284 short tons. The country also had 14 asbestos factories. While no figures have been available for several years it is interesting to note that the *Mining Journal* (London) gives the following statistics of production: 1920, 1478 metric tons; 1921, 2694 metric tons. There is a prospect, therefore, of Russia again becoming an important factor in the situation.

An extensive asbestos deposit in Mozambique has been reported.

Properties

Asbestos is distinguished from other minerals chiefly by its fibrous structure, and it is this structure that gives it its commercial value. Asbestos may be woven into fabrics or felted into sheets that are incombustible, and thus it is capable of rendering in many industries peculiar

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services for which no substitute materials may be employed. Mineralogically asbestos falls into various classes such as anthophyllite, chrysotile, crocidolite and amosite. Commercially asbestos falls into two great divisions, the spinning and the non-spinning fiber. Anthophyllite is chiefly non-spinning, while the other three varieties mentioned above have sufficient strength and flexibility for spinning purposes if the fiber is long enough. The spinning fiber may be subdivided into various classes, each depending on its quality and the nature of the product for which it is best adapted. Mixed fibers are commonly used. Chrysotile is generally regarded as the highest grade of spinning fiber, though with improved processes of fiberization and treatment good results are now being obtained from the use of crocidolite (blue asbestos) and amosite. The United States is the largest producer of finished asbestos in the world, but produces only a small proportion of its requirements of raw material, for which it depends to a large extent on the rich deposits of Quebec, Canada.

Asbestos fiber is classed in two groups known as crude fiber and mill stock. The crude fiber, which is graded as No. 1 and No. 2, is the longest material, which is broken from the rock by hand methods and is not passed through the mill. It is the highest grade of spinning fiber. Mill stock is the product obtained after the rock is crushed, passed through beaters and the fiber removed by screening or air separation. It falls into three or more grades according to the fiber length. The better grade of mill stock may be used for spinning purposes.

Uses

The chief uses of spinning fiber are for the manufacture of fireproof curtains, firemen's clothing and similar fabrics, rope, brakeband linings for automobiles, gaskets and packings. Asbestos fiber mixed with Portland cement is used in the manufacture of roofing shingles, floor-tile, wall-board, fireproof coverings for both wood and metal, fire-resisting cement and similar products. Rubber is used with asbestos in the manufacture of various types of packings. Asbestos cement is widely used for heat insulation on steam and water pipes, in cold-storage plants, and as a lining in safes, stoves and furnaces. Asbestos paper is used extensively in the building industries. In the laboratory asbestos is used for acid-filters, for stoppings in combustion-tubes, for fireproof supports and protectors, and for wicks in producing colored flame by saturation with mineral salts. Asbestos paper and twine soaked in sodium silicate and afterwards treated with calcium-chloride solution are used in the preparation of glass apparatus. There are many hundreds of minor uses distributed among a multitude of industries.

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ASPHALT

The growth in automobile traffic and the greater attention being devoted to road improvement is reflected in an increased demand for asphalt. A report prepared by the Asphalt Association of the United States and Canadian producers showed that in 1919 asphaltic types comprised 40.6 per cent. of street pavement in American cities, while if gravel and water-bound macadam pavements were eliminated from the consideration this percentage became 55.0. Asphalt, however, has many industrial uses other than that of a road material, including roofing, insulating, waterproofing, paint, pipe-coating, caulking, etc., and the field of use is being extended.

Most of the asphalt used in the United States is an artificial variety known as petroleum asphalt, made from residue obtained by distilling low-gravity oils, chiefly those of California, the Gulf Coastal fields, and Mexico. In 1921 the amount so produced was 1,532,313 short tons, of which 908,093 tons, or 60 per cent., was made from Mexican petroleum.

In comparison with this, the amount of native asphalt and bituminous rock produced was only 296,412 short tons in 1921, to which may be added imports of 128,535 tons. The native asphalt includes several varieties of related hydrocarbons. The relative importance of these is shown in the table of production of asphalt by varieties.

The sales of native asphalt and related bitumens in the United States in 1921 showed an increase of 49 per cent. in quantity and of about 64 per cent. in value over 1920. The sales of manufactured asphalt obtained from domestic petroleum decreased 11 per cent. in quantity and 25 per cent. in value. The sales of asphalt manufactured in the United States from Mexican petroleum decreased 13 per cent. in quantity and 18 per cent. in value.

The number of companies reporting the production of asphalt and related bitumens in 1921 was 44, of which 16 manufactured asphalt exclusively from petroleum of domestic origin, 10 used petroleum of Mexican origin, and 3 used petroleum from both sources.

The output of bituminous rock in 1921, reported by six operators (two each in California and Oklahoma, one each in Kentucky and Texas) was more than double the output in 1921. Gilsonite was reported from Uinta County, Utah; wurtzilite (elaterite) from Duchesne County, Utah; and grahamite from Pushmataha County, Okla.[1]

[1] U. S. Geol. Surv.

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MARKETED PRODUCTION OF NATURAL ASPHALT AND BITUMINOUS ROCK (a)
(In short tons)

Year.	Quantity.	Value.	Year.	Quantity.	Value.
1888	50,450	187,500	1905	72,898	305,242
1889	51,735	171,537	1906	73,062	674,934
1890	40,841	190,416	1907	85,913	928,381
1891	45,054	242,264	1908	78,565	517,485
1892	87,680	445,375	1909	99,061	572,846
1893	47,779	372,232	1910	98,893	854,234
1894	60,570	353,400	1911	87,074	817,250
1895	68,163	348,281	1912	95,166	865,225
1896	80,503	577,563	1913	92,604	750,713
1897	75,945	664,632	1914	79,888	642,123
1898	76,337	675,649	1915	75,751	526,490
1899	75,085	533,904	1916	98,477	923,281
1900	54,389	415,958	1917	80,904	735,924
1901	63,134	555,335	1918	60,034	780,808
1902	84,632	461,799	1919	88,281	682,989
1903	55,068	483,282	1920	198,497	1,213,908
1904	64,167	$420,701	1921	296,412	1,985,583

(r) U. S. Geol. Surv.

PRODUCTION OF ASPHALT BY VARIETIES
(In short tons)

Variety.	1919.		1920.		1921.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Bituminous rock	53,589	$262,309	132,353	$531,134	284,037	$1,788,715
Wurtsilite (elaterite)	(b)	(b)	(b)	(b)	(b)	(b)
Gilsonite	(b)	(b)	56,204	548,776	10,066	178,224
Grahamite	24,692	420,680	9,940	133,998	2,309	18,644
Maltha	(b)	(b)	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Ozokerite	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Total	88,281	682,989	198,497	1,213,908	296,412	1,985,581
Manufactured or oil asphalt (a)	614,692	8,727,372	700,496	11,985,457	624,220	9,048,223
Total	702,973	9,410,361	898,993	13,199,365	920,632	11,033,804

(a) This item includes material derived from petroleum of domestic origin only.
(b) Included with grahamite.

Deposits of asphalt and allied substances are found in Kentucky, West Virginia, Arkansas, Missouri, Oklahoma, Texas, Colorado, Nevada, Utah, and California. The richest and most extensive beds are in Oklahoma, but Utah contains the largest variety of bituminous substances. The stratigraphic range of the beds is as wide as the geographic, deposits being found in strata of all ages from the Ordovician to the Recent. The oldest asphaltic formations have been observed in Oklahoma, and the youngest, which consist of recently formed sands impregnated with bitumen, occur near Carpinteria, Calif., though small superficial deposits of brea are well distributed through the country. The largest deposits occur as impregnated rocks and veins.

The production of native asphalt by states in 1921 credited Utah with 10,371 short tons (gilsonite and wurtzilite or elaterite), and Oklahoma

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with 25,573 tons (bituminous rock and grahamite), while the remaining output of 260,468 tons (bituminous rock) came from California, Texas, and Kentucky. The corresponding figures for 1920 were: Utah, 63,522 tons; Oklahoma, 7522 tons; and other states, 127,453 tons.

ASPHALT PRODUCED FROM DOMESTIC PETROLEUM (a)
(In short tons)

Year.	Quantity.	Value.	Year.	Quantity.	Value.	Year	Quantity.	Value.
1903...	46,187	$522,164	1909.....	129,594	$1,565,427	1915.....	664,503	$4,715,583
1904...	44,405	459,135	1910.....	161,187	2,225,833	1916.....	688,334	6,178,851
1905...	52,369	452,911	1911.....	277,192	3,173,859	1917.....	701,809	7,734,691
1906...	64,997	615,406	1912.....	354,344	3,755,506	1918.....	604,723	8,796,541
1907...	137,948	1,898,108	1913.....	436,586	4,531,657	1919.....	614,692	8,727,372
1908...	119,817	1,540,396	1914.....	360,683	3,016,969	1920.....	700,496	11,985,457
						1921.....	624,220	9,048,221

(a) U. S. Geol. Surv.

ASPHALT PRODUCED IN THE UNITED STATES FROM MEXICAN PETROLEUM
(In short tons)

Year.	Quantity.	Value.	Year.	Quantity.	Value.
1914.....	313,787	$4,131,153	1918.....	597,697	$9,417,818
1915.....	388,318	3,730,436	1919.....	674,876	7,771,510
1916.....	572,387	6,018,851	1920.....	1,045,779	14,272,862
1917.....	645,613	7,441,813	1921.....	908,093	11,761,358

In the production of asphalt manufactured from domestic petroleum in 1920, California, with nine operators reporting, ranked first; Texas, with four operators reporting, ranked second; and Indiana, with three operators, ranked third in both quantity and value. These three States reported 82 per cent. of the total quantity and 80 per cent. of the total value.[1]

ASPHALT IMPORTED FOR CONSUMPTION INTO THE UNITED STATES (a)
(In short tons)

Year.	Crude.		Dried or Advanced.		Bituminous Limestone.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1913	(b) 207,033	$738,452	(c) 14,750	$133,336	6,395	$38,823	228,178	$910,611
1914	137,352	664,558	*Nil.*	.....	1,705	11,060	139,057	675,618
1915	135,276	680,537	*Nil.*	.....	2,976	19,001	138,252	680,357
1916	147,383	733,307	*Nil.*	.....	330	1,795	147,713	735,102
1917	187,473	978,640	*Nil.*	.....	413	15,028	187,886	993,668
1918	114,686	624,967	*Nil.*	.....	39	2,528	114,725	627,495
1919	104,914	609,923	*Nil.*	.....	735	5,576	105,649	615,499
1920	127,027	1,055,951	*Nil.*	.....	1,387	11,665	128,414	1,067,616
1921	116,450	972,166	*Nil.*	.....	12,085	157,124	128,535	1,129,290

(a) Bureau of Foreign and Domestic Commerce. (b) Includes dried or advanced asphalt for last 3 months of 1913. (c) Last 3 months of 1913 included in crude asphalt.

[1] U. S. Geol. Surv.

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ASPHALT IMPORTED INTO THE UNITED STATES BY COUNTRIES
(In long tons)

Imported from.	1919.		1920.		1921.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Europe:						
Germany						
Other Countries			1	$109	125	$1,889
North America:						
Canada	34	$1,088	78	2,832	9	1,188
Mexico	5,863	31,587	13	66	16	634
West Indies:						
British	45,619	353,500	90,040	892,545	68,127	773,463
Cuba	568	17,270	244	7,447	331	7,020
South America:						
Colombia	5	169	6	207	16	1,556
Venezuela	42,240	211,875	24,267	156,282	46,139	343,535
Total	94,329	615,499	114,649	1,067,616	114,763	1,129,290

MINERAL WAX IMPORTED FOR CONSUMPTION IN THE UNITED STATES (a)

Year.	Quantity, Pounds.	Declared Value.	
		Total.	Price per Pound.
1914	8,191,529	$498,695	$0.061
1915	2,845,304	214,495	0.075
1916	3,047,834	200,377	0.066
1917	899,405	90,510	0.101
1918	1,809,459	147,805	0.082
1919	3,747,480	454,840	0.082
1920	4,272,341	499,758	0.117
1921	8,548,542	546,054	0.064

(a) U. S. Bureau of Foreign and Domestic Commerce.

The imports of ozokerite and other mineral waxes in 1921 increased 100 per cent. in quantity but only 9 per cent. in value over those of 1920; they also exceeded the imports of 1914 by 4 per cent. in quantity and 9 per cent. in value.

EXPORTS

According to the records of the Bureau of Foreign and Domestic Commerce, the export trade of the United States in unmanufactured asphalt in 1921 decreased about 12 per cent. in quantity and 13 per cent. in value, compared with that of 1920. The value of the manufactured asphalt exported decreased about 26 per cent. and the decrease in the total value of the asphalt exported was about 18 per cent.

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DOMESTIC ASPHALT EXPORTED FROM THE UNITED STATES (a)

Year.	Unmanufactured.		Manufactures, Value.	Total Value.
	Quantity, Short Tons.	Value.		
1914	41,716	$845,838	$401,182	$1,247,020
1915	42,787	735,952	438,685	1,174,637
1916	40,816	759,769	494,895	1,254,664
1917	30,113	586,673	586,055	1,172,728
1918	19,739	577,654	577,936	1,169,402
1919	35,900	1,103,930	606,918	1,710,848
1920	46,166	1,356,116	842,074	2,198,190
1921	40,506	1,178,038	621,224	1,799,262

(a) Dept. of Commerce.

Consumption

It is impossible to arrive at an exact statement of the asphaltic material consumed, but if from the sum of the quantity produced from domestic deposits and manufactured from domestic and Mexican petroleum plus the quantity imported is taken the quantity exported in a given year, the result reached is approximately correct. The following table gives the figures so obtained for the years 1916 to 1921, inclusive:

ASPHALTIC MATERIAL CONSUMED IN THE UNITED STATES

	Short Tons.		Short Tons.
1916	1,467,657	1919	1,445,178
1917	1,587,284	1920	2,023,665
1918	1,356,009	1921	1,916,205

During the past eight years, 5,000,000 tons of asphalt and asphaltic materials have gone into American highways—a quantity sufficient for 50,000 miles of roads and streets, or double the entire mileage of the Route Nationale, the main highway system of France. The asphaltic-treated highways in the United States, if connected in one great roadway 16 ft. wide, would twice circle the globe.

According to J. E. Pennybacker, secretary of the Asphalt Association, the price of asphalt during the years 1915 to 1920 increased only 65 per cent., while highway labor increased 150 per cent. and the price of other road materials rose from 90 to 150 per cent.

New Construction.—The new plant of the General Asphalt Co. erected at Maurer, N. J., at a cost of about $3,000,000 was completed late in 1921 and has not yet had time to demonstrate the saving which will result from its greater efficiency and more modern equipment.

The asphalt plant of the Freeport Sulphur Co., at Freeport, Texas, has begun operations and the first shipments made. The plant is not yet entirely completed. When finished it will have four stills.

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Foreign Sources

Austria.[1]—The export of 44,092 lb. of ozokerite, worth $10,100, from Austria to the United States during the year 1920 and 223,584 lb., worth $43,140, during 1921 is reported by Consul C. H. Foster at Vienna. Ozokerite, which sells for 21 cts. a lb. in Vienna, is shipped to New York via Bremen in bags containing 84.32 lb. each.

Madagascar.[2]—A number of mining claims for hydrocarbons have been made by foreign prospectors. A number of signs seem to indicate that these exist in the west of Madagascar: the bitumen seepages are very numerous; ozokerite is found in the region of Morafenobe; salt water is met with there also; all these conditions are favorable to the existence of hydrocarbons.

Palestine.[3]—Bitumen is gathered in Palestine from the Dead Sea, where it is found floating on the surface of the sea. Prior to the war this bitumen was gathered and turned over to an American, who lived in Jerusalem, who in turn exported it by special permit. It is said that the annual export amounted to approximately 50 tons, and that practically the entire output was sent to Germany, where it was used in preparing the gloss for patent leather. At present very little of this bitumen is being gathered, but it is possible that by using dynamite or other depth charges, large quantities might be obtained out of the Dead Sea.

Poland.[4]—The production of ozokerite has fallen off very greatly. In 1921 only 260 metric tons was produced, whereas in 1920 the output amounted to 440 tons, and before the war from 2000 to 3000 tons annually.

The ozokerite is found in Galicia, in Miocene salt clay strata, like those at Boryslaw and Truskawiec. This petroleum wax is sometimes in strata of only a few centimeters, but the strata sometimes attain a depth of 30 meters. As the superimposed strata are not of very solid construction, mining operations are easy and are carried out in the Drohobycz and Stanislawów districts.

In 1913 there were 28 shafts in operation. The ozokerite obtained from these was melted on the spot and delivered to the kerosene and paraffin factories. In the same year 686 tons was dispatched to Germany, Russia, America, and Switzerland, while 659 tons was worked up in the country.

The output of ozokerite since 1900 was as follows:

	Metric Tons.		Metric Tons.
1900	2,004	1910	2,171
1901	2,707	1911	1,940
1902	2,655	1912	1,683
1903	2,849	1913	1,353
1904	3,086	1914	810
1905	2,957	1915	59
1906	2,698	1916	246
1907	2,508	1920	440
1908	2,593	1921	260
1909	2,115		

[1] *Comm. Rept.*, Apr. 24, 1922.
[2] *Bull. Economique*, Tananarive; *Comm. Rept.*, Apr. 17, 1922.
[3] *Comm. Rept.*, Aug. 31, 1921.
[4] *Comm. Rept.*, Aug. 10, 1921.

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Trinidad.[1]—Shipments of asphalt during 1920 amounted to nearly 113,697 tons, as against 66,742 tons in 1919. The principal markets were the United States and the United Kingdom, which in 1920 took, respectively, 86,280 and 21,770 tons. During 1921, however, there has been a considerable falling-off in exports, due chiefly to depressed business conditions in the United States (the principal market) and to competition with the residual asphalt products of Mexican refineries.

TOTAL EXPORTS OF ASPHALT FROM TRINIDAD
(In long tons)

Year.	To United States.			To Europe.			To Other Countries.			Grand Total.
	Lake.	Land.	Total.	Lake.	Land.	Total.	Lake.	Land.	Total.	
1912	95,111	8,600	103,711	85,299	.....	85,299	486	.....	486	189,496
1913	123,873	1,400	125,273	104,153	....	104,153	605	.....	605	230,031
1914	67,357	2,950	70,307	75,297	.....	75,297	.....	.....	.....	145,604
1915	118,001	1,250	119,251	18,025	... ..	18,025	.....	.....	.....	136,026
1916	117,719	.....	117,719	13,380	.....	13,380	.....	.....	.....	131,099
1917	119,149	.....	119,149	11,496	.....	11,496	.....	.....	.....	130,645
1918	58,528	.....	58,528	14,552	.....	14,552	.....	.....	.....	73,080
1919	.....	.....	.....	.....	.....	.....	.....	.....	.....	66,742
1920	.....	.....	86,280	.....	.....	27,417	.....	.....	.....	113,697

Venezuela.—Asphalt deposits, formed by the evaporation of the volatile parts of oil rising to the surface, are found in various parts of Venezuela and on the island of Trinidad. The two great sources of the asphalt of commerce are Trinidad Lake, on the island of that name, and Bermudez Lake, in Venezuela, about 30 miles inland on the mainland across from Trinidad. The latter is much larger, covering about 2000 acres, compared with about 120 acres for the former, but Trinidad has been the chief source of past exports, shipments amounting to 130,000 to 230,000 tons annually as compared with 25,000 to 95,000 tons from Venezuela. Venezuela has other deposits besides Lake Bermudez, several of which have been worked. One is located as far west as the Limon River, 50 miles west of Maracaibo.

The production of asphalt in Venezuela by companies in recent years is shown in the following table:[2]

ASPHALT PRODUCED IN VENEZUELA
(In metric tons)

Company.	Location.	1917.	1918.	1919.
New York & Bermudez Co....	Guanoco, State of Sucre.....	52,991	46,453	45,932
South American Company ...	Gen. Urdaneta and of Lagunillas, State of Zulia	72	50	.....
Cià. Anonima Minerales Petroliferous Riopauji.....	Rio Pauji, State of Trujillo	1,009	.....	.....
Total.....		54,072	46,503	45,932

[1] Suppl. to *Comm. Rept.*, 1921.
[2] *Eng. Min. Jour.*, Feb. 19, 1921.

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The asphalt lake in Venezuela is worked by the New York & Bermudez Co., a subsidiary of the General Asphalt Co. Most of the output is exported to the United States. Exports for several years are shown below:

	Quantity, Short Tons.	Value.
1906	24,783	$98,250
1907	42,153	167,938
1908	35,324	141,912
1909	41,767	180,061
1910	35,717	151,000
1911	56,183	238,000
1912	73,780	312,000
1913	93,884	400,000
1914	49,941	.....
1915	31,949	.....
1916	49,176	.....
1917	54,410	.....
1918	47,314	.....
1919	41,582	.....

WORLD'S PRODUCTION OF ASPHALT AND BITUMINOUS ROCK (a)
(In metric tons)

Asphalt.

Year.	France.	Germany.	Hungary.	Italy. (c)	Spain.	Trinidad. (b)	United States. (c)	Total.
1911...	38,000	81,902	3,861	50,179	3,495	163,080	40,307	380,824
1912...	31,535	96,112	4,460	52,707	6,087	176,077	37,570	403,338
1913...	30,892	105,500	3,024	56,750	5,695	208,164	31,310	441,335
1914...	22,170	81,800	.....	33,752	4,148	147,942	26,147	315,959
1915...	10,179	32,400	.....	25,201	2,671	138,210	28,506	237,167
1916...	17,559	31,500	.....	16,662	2,591	133,204	32,028	233,544
1917...	12,964	12,321	.....	13,606	1,950	132,742	35,367	208,952
1918...	11,961	7,980	.....	8,310	2,367	74,254	31,469	136,341
1919...	11,065	12,600	.....	14,872	2,385	67,817	31,475	140,214
1920...	22,252	.....	.....	29,015	.....	115,528	50,988	.....

Bituminous Rock.

Year.	Austria.	France.	Hungary.	Italy.	Spain.	United States.	Total.
1911.....	1,740	169,697	(d)60,000	183,133	.....	38,704	464,774
1912.....	4,234	312,000	(d)50,000	181,397	.....	49,691	597,322
1913	3,026	324,610	45,860	171,097	.....	(f)52,220	601,451
1914	.....	166,125	.....	119,853	5,765	44,257	.....
1915.....	.....	66,831	.....	47,650	4,521	40,210	.....
1916.....	.....	98,480	.....	16,829	7,316	57,311	.....
1917.....	.....	116,679	.....	8,645	.....	38,028	.....
1918.....	.....	104,234	.... 17,600.,.	22,309	8,395	22,994	175,532
1919.....	.....	.....	.....	78,000	10,091	48,616	.....
1920.....	.....	.....	.....	106,642	.....	120,071	.....

(a) Statistics of production in Barbados, Cuba, Mexico, Russia, Switzerland, and Venezuela are not available. (b) Exports. (c) Including mastic and bitumen. (d) Estimated. (e) Previously the U. S. statistics included oil asphalt. This is now omitted, leaving only the natural asphalt. (f) Includes some maltha.

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BARIUM AND STRONTIUM

By J. B. Pierce, Jr.

Barium

Barytes.—The barytes mining industry suffered severely in 1921, both from general business depression and foreign importation. Undoubtedly there will be shown a decided shrinkage in production for 1921 from the surprisingly high record for 1920 of 228,113 short tons. Detailed figures for 1921 are not available at the time of writing.

The following tables show the detailed production, consumption and importation figures covering crude barytes for recent years:

CRUDE BARYTES PRODUCED AND MARKETED IN THE UNITED STATES (*a*)
(In short tons.)

	Quantity.	Value.	Average Price per Ton. (*b*)
Annual average, 1880–1889	21,410	.....	.....
Annual average, 1890–1899	27,523	.....	.....
Annual average, 1900–1909	58,310	.....	.....
Annual average, 1910–1914	43,389	.....	$3.31
1915	108,547	$381,032	3.51
1916	221,952	1,011,232	4.56
1917	206,888	1,171,184	5.66
1918	155,368	1,044,905	6.73
1919	209,330	1,727,822	8.25
1920	228,113	2,142,464	9.39

(*a*) U. S. Geol. Surv. (*b*) F.o.b. mine shipping point.

CRUDE BARYTES MARKETED IN THE UNITED STATES[1]

State.	1918.			1919.			1920		
	Quantity (Short Tons).	Value.	Average Price Per Ton.	Quantity (Short Tons).	Value.	Average Price per Ton.	Quantity (Short Tons).	Value.	Average Price per Ton.
Alabama	1,794	$9,976	$5.56	(*a*)	(*a*)	(*a*)	(*a*)	(*a*)	(*a*)
Georgia	69,138	418,178	6.03	85,303	$667,521	7.83	84,644	$790,362	$9.27
Kentucky	(*a*)	(*a*)	(*a*)	5,435	36,408	6.70	(*a*)	(*a*)	(*a*)
Missouri	49,094	393,738	8.02	73,247	640,398	8.74	99,654	1,013,570	10.17
California	(*a*)	(*a*)	(*a*)	(*a*)	(*a*)	(*a*)	2,250	20,850	9.27
Tennessee	22,542	141,844	6.29	34,700	288,622	8.32	29,319	213,657	7.29
Other States(*b*)	12,620	81,169	6.43	10,645	94,873	8.91	12,246	104,025	8.49
	155,368	1,044,905	6.73	309,330	1,727,822	8.20	228,113	2,142,464	9.39

[1] U. S. Geol. Surv.
(*a*) Included in "Other States."
(*b*) Includes Alabama, Kentucky, Nevada, New Mexico, North Carolina, South Carolina, Virginia, Wisconsin, and California.

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CRUDE BARYTES IMPORTED FOR CONSUMPTION[1]

Year.	Quantity (Short Tons).	Value.	Year.	Quantity (Short Tons).	Value.
1914	24,423	46,782	1918	*Nil.*	*Nil.*
1915	2,504	4,877	1919	118	$594
1916	17	245	1920	24,874	146,858
1917	6	63	1921	11,054	59,371

[1] Bur. of Foreign and Domestic Commerce.

CRUDE BARYTES USED IN THE MANUFACTURE OF BARIUM PRODUCTS[1]

	For Barium Chemicals.	For Ground Barytes.	For Lithopone.	Total.
1916	38,283	75,507	71,898	185,688
1917	49,842	60,132	86,065	196,039
1918	38,041	62,440	85,282	183,783
1919	32,976	64,922	103,688	201,586
1920	37,210	79,052	113,181	229,443

[1] U. S. Geol. Surv., short tons

WORLD'S PRODUCTION OF BARIUM MINERALS
(In metric tons.)

	1915.	1916.	1917.	1918.	1919.	1920.
Rhodesia	.....	.....	.....	49	.....	.....
Canada	499	1,241	3,166	581	*Nil.*	681
India	.....	.....	.....	2,768	2,632	689
Australia	374	1,244	1,275	2,070	2,828	3,648
Bavaria	7,143	12,484	10,199	5,508	8,802	.....
Italy	17,850	21,650	19,000	14,945	19,390	15,380
Spain	4,218	10,508	10,147	4,170	11,459	.....
United Kingdom	63,483	77,258	66,612	67,428	61,054	65,183
United States	98,500	202,355	187,689	140,834	172,370	206,944

The year 1921, for the first time since 1915, witnessed a drop in price of crude barytes. This reduction varied from $2.50 to $1.25 per long ton at the mines, making crude barytes sell for from $6.50 to $8.00 per long ton, f.o.b. mines.

Undoubtedly the importation of foreign ore hurt the consumption of the domestic product along the seaboard, as high transportation costs from the mines make competition difficult. Efforts were being made to get freight reductions, which, while partially successful, were not effective until early in 1922, thus not affecting the 1921 business.

During the year no changes were introduced into the methods of mining crude barytes. Steam-shovels in the larger open-pit operations, and hand labor with or without aid of mechanical haulage in the smaller operations, prevailed as in former years.

The Engineering and Mining Journal of Dec. 3, 1921, under the heading "Preparation and Uses of Barytes," described the deposits, mines and method of operation in the United States.

The South Australia Department of Mines publication for 1921,

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under the heading "Notes on the Preparation of Barytes for the Market," gives a complete outline of the mining, grinding, bleaching and marketing of barytes.

Canadian Chemistry and Metallurgy, August, 1921, notes the different Canadian deposits and the extent of work done on them during 1921.

The Summary Report of the Canadian Department of Mines for 1920, published in 1921, gives an account of an examination of several barytes deposits in northern Ontario, made in order to complete data for a report on "Barium and Strontium in Canada," by Hugh S. Spence, to be published shortly. None of the properties examined in 1920 has attained the producing stage, the majority being situated too far from a railroad to permit of being worked under present conditions.

The Imperial Mineral Resources Bureau's publication, "The Mineral Industry of the British Empire and Foreign Countries, War Period, Barium Minerals, 1913–1919," gives a complete and detailed account of the barytes mined, descriptions of deposits and mines, production and uses of barytes, together with complete tables showing production by years and countries for England and Europe.

Barium Products.—Largely owing to lack of adequate tariff protection, and to a lesser degree by adverse general business conditions, the barium industry suffered severely during 1921. Some of the plants were closed the entire year and others were completely closed part of the year and operated only part time the remainder of the year.

The effect of failure to afford proper tariff protection can be readily understood by the following tables, when it is remembered that importations for 1920 were practically confined to the last quarter of the year only. Importation figures for 1921 in all items greatly exceeded those of 1920, as given in the following tables.

Detailed figures of 1921 domestic production are not available at time of writing, but the estimate given in the table is believed to be liberal.

BARIUM CHEMICALS OF DOMESTIC MANUFACTURE SOLD
(In short tons)

Chemical.	1916.	1917.	1918.	1919.	1920.	1921. (c)
Barium binoxide	1,980	2,555	1,047	858	(a)	(a)
Barium carbonate	6,844	8,238	7,661	7,135	7,484	1,500
Barium chloride	3,643	4,870	4,530	4,509	3,084	500
Barium nitrate	446	165	137	784	(a)	(a)
Barium sulphate (blanc fixe)	3,337	6,314	9,022	5,227	6,946	2,500
Other barium chemicals (b)	542	361	289	1,500	2,951	1,000
	16,792	22,503	23,186	20,013	20,465	5,500

(a) Included under "Other barium chemicals." (b) Includes, 1916: Hydroxide and sulphide; 1917: Hydroxide and sulphide; 1918: Hydroxide and sulphide; 1919: Sulphide; 1920 and 1921: Binoxide, hydroxide, nitrate and sulphide. (c) Estimated.

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IMPORTS OF BARIUM PRODUCTS
(Fiscal year, ending June 30)

	1919.		1920.		1921.(a)	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Baryta, sulphate of, or barytes including baryta earth:.....						
Unmanufactured, long tons.....	105	$594	2,058	$10,405	9,870	$59,371
Manufactured, long tons.....	Nil.	Nil.	107	653	895	16,942
Blanc fixe, or artificial sulphate of barytes, and satin white or artificial sulphate of lime, pounds.....	1,285	90	41,108	1,267	1,538,383	22,470
Lithopone, pounds.....	1,477,296	122,708	2,288,955	170,522	10,493,938	432,019
Barium carbonate, pounds.....	8,549	2,666	163,509	18,268	4,475,225	80,603
Barium binoxide, pounds.....	Nil.	Nil.	70,862	12,367	425,252	37,588
Barium chloride, pounds.....	1,099,686	19,756	2,520,321	71,988	4,372,939	72,621

(a) Calender year.

Lithopone.—Lithopone manufactured and sold in 1920 was 89,373 short tons, valued at $12,484,925. The 1921 production cannot be easily estimated, but it will probably be less than 1920, although much greater in proportion than barium products, as this industry is more firmly established and better able to compete with foreign competition.

PRODUCTION AND CONSUMPTION OF LITHOPONE IN THE UNITED STATES

Year.	Production. (a)		Imports. (b)		Consumption (Pounds).
	Quantity (Pounds).	Value.	Quantity (Pounds).	Value.	
1911.....	33,732,000	$1,243,108	6,355,312	$166,199	40,087,312
1912.....	48,440,000	1,702,119	5,904,475	153,303	54,344,475
1913.....	59,370,000	2,170,445	4,504,423	122,063	63,424,423
1914.....	65,638,000	2,490,530	7,544,148	259,955	73,182,148
1915.....	92,988,000	3,760,472	4,087,826	137,816	97,075,826
1916.....	102,582,000	5,798,927	4,681,560	405,730	107,263,560
1917.....	127,426,000	7,394,531	448,000	29,199	127,874,000
1918.....	124,806,000	7,923,209	.....	.....	124,806,000
1919.....	156,730,000	10,218,850	1,477,296	122,708	158,207,296
1920.....	198,746,000	12,484,925	3,427,321	263,240	202,273,321

(a) 1911 to 1918, inclusive, from "Mineral Resources," U. S. Geol. Surv. 1919 from reports submitted to the Tariff Commission by individual manufacturers. (b) From 1910 to Oct. 3, 1913, listed as "white sulphide of zinc."

STRONTIUM

Strontium Ore.—A new deposit of celestite in Utah was reported, and samples submitted tested 98 per cent. $SrSO_4$. So far as is known, no ore was mined.

No production of celestite in the United States has been reported for 1921 and no strontium ore was mined in the United States in 1920. Most of the ore that has been produced in the United States has been mined in California, Arizona, Texas, and Washington. Most of the ore was celestite (strontium sulphate), but part of that mined in California and Washington was strontianite (strontium carbonate).

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STRONTIUM ORE MARKETED AND IMPORTED IN THE UNITED STATES (a)
(In short tons)

Year.	Production.	Value.	Imports, Pounds.	Imports, Value.
1916	250	$3,650	(b)	$11,049
1917	4,035	87,700	(b)	23,216
1918	400	2,000	(b)	2,459
1919	*Nil.*	*Nil.*	1,225,952	3,380
1920	*Nil.*	*Nil.*	1,659,083	15,479
1921	*Nil.*	*Nil.*	1,212,758	4,393

(a) U. S. Geol. Surv. (b) Quantities not available. Imports represent strontium oxide and carbonate. The imports of ore cannot be determined from the records.

A new deposit of celestite on tidewater in British Columbia was reported in *Canadian Chemistry and Metallurgy*, July, 1921.

The celestite deposit in Bagot township, Renfrew County, Ontario, described in Mines Branch Summary Report, 1919, was again visited, late in the season. Considerable mining was done on the deposit during 1920, and a small experimental mill was erected, to grind the material. Some shipments were made to domestic paint firms, and the celestite is reported to have substituted satisfactorily for barytes in paints. The ore of this deposit is very mixed, consisting of irregular, detached masses of fibrous and rather friable celestite, enclosed in a dolomite matrix. It is probable that this mode of occurrence will alter in depth to a more regular vein formation, as the detached masses of celestite at the surface appear to be portions of a brecciated vein. All of the celestite recovered is secured by hand cobbing, and the actual amount of celestite recoverable by this means from the mixed celestite-dolomite cobbing ore probably does not exceed 30 per cent. of the total present. The remaining celestite is present intimately mixed with dolomite, and the mixed rock would require to be concentrated in order to effect a satisfactory recovery. Such mixed rock averages about 50 per cent. celestite.[1]

Production of Strontium Salts.[1]—Strontium salts were made from strontium ore at only two plants in the United States in 1920, one in New Jersey and one in Missouri. Some of the ore used in these factories was ground to a fine powder in other mills before it was used in the chemical plants. Strontium compounds made in some other factories were manufactured not from ore but from chemically prepared strontium salts bought in the market. Plants in New York and Pennsylvania that formerly manufactured strontium compounds from ore did not produce any in 1920.

The ore used in the two chemical factories was celestite imported from England. Strontium nitrate, used mainly in pyrotechnics and signal lights, was the chief product made. Strontium bromide, salicylate,

[1] Summ. Rept., 1920, Can. Dept. of Mines.
Min. *Res. of the U. S.*, 1920, Part II.

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carbonate, chloride, and hydroxide were also made in these factories About twice as much celestite was used in the manufacturing plants in 1920 as the average used in recent years, and the total quantity of chemicals produced exceeded that produced in any other year except 1918.

STRONTIUM CHEMICALS MANUFACTURED FROM DOMESTIC AND IMPORTED CRUDE ORE IN THE UNITED STATES AND MARKETED IN 1916–1921, IN POUNDS (a)

1916	2,006,000	1919	2,191,409
1917	2,499,676	1920	4,713,015
1918	4,927,000	1921	847,368

(a) U. S. Geol. Surv.

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BISMUTH

By A. T. Ward

Bismuth is used principally in the making of low-fusing alloys, such as for stereotype metals, plugs for automatic fire-sprinklers, dies from fresh plaster impressions (dentistry), settings of Wood's metal (with cadmium) for crystal detectors in radiophone receiving sets, etc.; bismuth salts are widely used in medicine for correcting digestive disorders.

The sources of supply of bismuth ores are principally Bolivia (associated with tin ores), Peru, Australia, and China (associated with tungsten ores).

There was a limited production of bismuth ores during the war period in Rhodesia (Hay mine, Mazoe) and in Burma (in the Tavoy, Amherst, Mergui, Bihar, and Orissa districts).

By far the larger part of the bismuth produced in America is obtained as a by-product of electrolytic lead refining by the Betts process, and electrolytic refining of Bolivian tin. Some is also recovered from re-treatment of fume recovered in Cottrell precipitators at copper smelters.

The principal producers in the United States are the U. S. Smelting, Refining & Mining Co. and the American Smelting & Refining Co., which control the market in this country. The production elsewhere is controlled principally by Johnson, Matthey & Co., Ltd., of London, who supply large quantities of the metal to British and continental chemical manufacturers.

There has been little development in the matter of the working of bismuth ores. It is reported[1] that during 1920 the Sells mine at Alta, Utah, produced ore containing 8517 lb. of bismuth, while other similar sources were at Eureka and Pioche, Nev., and the Silver district, Yuma County, Arizona.

The mineral pucherite ($BiVO_4$) was reported in 1921 as being found in the Sierra de Famatima (La Rioja), Argentine Republic. In addition, various other occurrences of bismuth minerals were noted in Catamarca, San Luis, Cordoba, and San Juan, some of which have been exploited on a small scale.[2]

[1] Bismuth, by Victor C. Heikes, *Min. Res. of the U. S.*, 1920, U. S. Geol. Surv.
[2] *Yacimientos de Materias Explotables de la Rep. Argentina*, Boletin No. 26, Series B, Buenos Aire. 1921.

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The latest data on the world's production of bismuth minerals are given in the accompanying table. The United States production during 1921 is estimated at 232,000 lb.; no data for production elsewhere in 1921 are available.

The Fordney tariff measure of July 21, 1921, proposed a duty of 25 per cent. *ad valorem* on bismuth salts, in place of 10 per cent. as now in effect in the Underwood law.

The (British) Imperial Mineral Resources Bureau during 1920 published a very useful monograph on bismuth production, prices, bibliography, etc., covering the war period (1913–1919).

IMPORTS OF BISMUTH INTO THE UNITED STATES

Year.	Quantity, Lb.	Value.
1911	178,298	$321,360
1912	166,980	305,282
1913	151,030	257,176
1914	133,190	241,448
1915	34,237	72,587
1916	64,821	155,925
1917	88,465	196,113
1918	85,611	208,098
1919	76,539	228,376
1920	75,781	97,489
1921	94,085	114,891

(a) Dept. of Commerce.

WORLD'S PRODUCTION OF METALLIC BISMUTH AND BISMUTH MINERALS
(In metric tons)

Year.	United States, Metal.	Australia. (c)		Bolivia. (c)		Argentina, Ore. (e)	Peru, Metal. (b)	Spain, Ore.	Japan, Ore. (c)
		Ore and Metal.	Bi-W Conc.	Ore, Conc. and Residues.	Metal.				
1909	.....	19.2	.....	.....	.....	.....	30.3	76.5	.....
1910	.....	27.8	.....	.....	.....	.....	24.1	52.0	.....
1911	.....	18.0	.....	550	.....	.....	24.4	51.0	.....
1912	.....	11.0	.....	478	.....	.....	51.0	71.7	.....
1913	.....	15.3	185	422	.....	.....	25.3	55.0	.....
1914	.....	31.5	195	550	.....	.....	11.2	39.3	3.1
1915	.....	27.4	251	663	.....	.....	.....	16.7	7.1
1916	.....	37.6	139	670	.....	18.0	.....	10.8	1.0
1917	.....	29.5	133	280	255.0	275.7	1.4	13.7	1.0
1918	.....	37.6	116	143	249.0	28.0	.....	33.4	1.0
1919	145(a)	23.4	142	374	.....	.....	.....	75.0	.....
1920	114(a)	78.0	49	.....	18.4(d)	.....	7.8	.....	.....

Miscellaneous production: Rhodesia, up to 1918, 4.07 tons of ore; India, 1917, 0.51 tons of metal; Norway, 1915, 1917, 20.0 tons of ore; China, 1919, 86 tons of ore (estimated).
(a) Estimate. (b) From *Estadistica Minera del Peru.* (c) 1913–1919, Imperial Mineral Resources Bureau, London, 1920. (d) *Eng. Min. Jour.* (e) *Estadistica Minera de la Republica* (Argentina), Boletin 14, Series A (Minas), 1921.

In Bolivia the ore consists of both native bismuth and the sulphide, and is found associated especially with tin deposits and also with silver and copper. Production comes mainly from mines at Tasna, Chorolque

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and Huayna Potosi. Since 1914 exports of bismuth have ranged between 350 tons and 680 tons, valued at $850,000 to $1,600,000. Peru has a single mine, in the Department of Junin, whose reserve is said to be sufficient to supply the world for many years. The ore consists of oxidized bismuth compounds, averaging 3 per cent. bismuth. In Chile bismuth has been reported from the Province of Atacama, as a sulphide. In Brazil it occurs in the gold mines of Minas Geraes, both as native bismuth and the oxide, and is reported from the State of Rio Grande do Sul. The State of Lara, in Venezuela, has bismuth deposits.[1]

Prices.—In January, 1921, the price of bismuth in 500-lb. lots was quoted as $2.40 per lb. In February the price varied from $2.35 to $2.40 per lb., but in March it dropped to $1.50 per lb., at which it was quoted until the end of the year.

[1] *Chem. Met. Eng.*, Apr. 19, 1922.

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BORAX

By A. T. Ward

Borax or sodium borate, or derivatives thereof, are used principally in the following ways, importance of consumption being in the order given: (1) In the pottery and enamel industries, for glazes and enamels (borax); (2) in the manufacture of glass (borax and boric acid); (3) in the manufacture of soap (borax); (4) in the tanning and glue industries (borax and boric acid); (5) in the food industry, as a preservative (boric acid and borax); (6) for surgical dressings and as an antiseptic in medicine (boric acid); (7) in the paper and linen industries, for glazes (borax); (8) in laundries as a cleanser, and in conjunction with starch for imparting glosses (borax); (9) in various metallurgical industries, as a flux (borax), slagging element (anhydrous borax), deoxidizer (boron fluoride), and as an agent for hardening and strengthening metals (free element, boron); (10) in the paint and pigment industry (borate of manganese, lead, and chromium), and for preparing and preserving distemper (borax and boric acid); and (11) in the manufacture of sodium perborate (borax).

Fully half of the borax produced is used in the pottery and ename industries, where the various percentages in the enamel mixes used are:

	Per Cent.
Gray-ware enamels	28.5
Ground coats	30.0
White cover enamels	28.0
Colored enamels	29.0

The production of boron ores in 1921 was approximately 50,000 short tons valued at $1,320,000. This represents a decrease of over 58 per cent. from the quantity shipped in 1920. The output was borax (sodium borate) from Trona, San Bernardino County, Calif., and colemanite (calcium borate) from Death Valley Junction, Inyo County, and Lang, Los Angeles County, Calif., and Dike, Clark County, Nevada.

Exports of borax during 1921 were 4,063,683 lb., of a value of $270-127, as against 14,325,037 lb., of a value of $1,206,936 in 1920.

The larger part of the United States production of borax came from the colemanite deposits of the Furnace Creek region of Death Valley, California, discovered in October, 1882. Most of the low-grade ore is shipped to the mill and concentrator at Death Valley Junction, 20

[1] Private communication, F. M. Smith.

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miles to the east of Death Valley; the higher grades are shipped direct to refineries at Bayonne, N. J., and Oakland, Calif. These properties are owned and operated by the Pacific Coast Borax Co., which is controlled by Borax Consolidated, of London.

Early in 1921 the West End Chemical Co. under the direction of President F. M. Smith, who was the founder of the Pacific Coast Borax Co. and Borax Consolidated, London, and for many years the active head of these interests, purchased the colemanite deposits in the Callville Wash, Clark County, Nevada, discovered in 1920. According to Hoyt S. Gale,[1] this is "the first record of occurrence of commercial deposits of the mineral colemanite outside of the State of California, not only in the United States but apparently in the whole world." The same authority states, "This is, I believe, the largest individual deposit of colemanite that I know of." The ore from this deposit is calcined at the mine, which is located about 20 miles from the main line of the Salt Lake Railroad (Union Pacific System), and shipped direct to the company's refineries at San Francisco, Calif., Chauncey, N. Y., and other Eastern and European localities, where it is manufactured into borax and boric acid.

The discovery of the Callville Wash deposit is reported as being a direct result of scientific prospecting following the location in the Fall of 1920 of a smaller colemanite deposit in the White Basin, also in Clark County, Nevada.[2]

UNITED STATES IMPORTS OF BORAX, ETC.
(Fiscal years ending June 30, except 1921)

Year.	Borax.		Borate of Lime, Etc.		Boracic Acid.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1915	*Nil.*		*Nil.*		401,684	$18,002
1916	*Nil.*		*Nil.*		424,219	22,145
1917	83	$3	*Nil.*		404,210	24,590
1918	*Nil.*		*Nil.*		195,650	14,087
1919	*Nil.*		550	$25	280,935	31,190
1920	*Nil.*		*Nil.*		253,958	11,165
1921	90	12	7,840,000	167,500	605,330	43,044

PRODUCTION OF BORATE ORES IN CALIFORNIA (*a*)
(In tons of 2000 lb.)

Year.	Tons.	Value.	Year.	Tons.	Value.	Year.	Tons.	Value.
1907	53,412	$1,200,913	1912(*d*)	42,315	$1,127,313	1917(*d*)	108,875	$3,609,632
1908	22,200	1,117,000	1913(*d*)	58,051	1,491,580	1918(*d*)	88,794	2,179,830
1909	16,628	1,163,960	1914(*d*)	62,400	1,464,400	1919(*d*)	66,146	1,380,000
1910(*d*)	42,357	1,201,842	1915(*d*)	67,003	1,677,099	1920(*d*)	120,320	2,173,000
1911(*d*)	53,330	1,569,151	1916(*d*)	103,525	2,409,459	1921(*d*)	50,000	1,320,000

(*a*) Reported by the California State Mining Bureau. (*d*) U. S. Geol. Survey, crude.

[1] *Eng. Min. Jour.*, Oct. 1, 1921.

[2] *Bull.* 735-B, U. S. Geol. Surv.

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A description of the Curry County, Oregon, deposit of priceite, ($5CaO.6B_2O_3.9H_2O$), owned by the Pacific Coast Borax Co., and not now in operation, was published during the year.[1]

Borax in Foreign Countries

Chile, Peru, and Bolivia.—The production of borax (ulexite) in these countries is reported as being 17,377 metric tons, only 350 tons more than during 1920, the increase being principally in the Peruvian tonnage. Borax Consolidated, as expected, maintained its strong position.

The borates are found in the beds of dried-up lakes called *salares*, some of which contain millions of tons of crude borax. Because of transportation costs very few of these are worked, Chile's production, which normally was 40,000 tons annually, coming almost entirely from the Salar de Ascotan.

Argentine.—The Belgian International Borax Co. is reported as having produced 2119 metric tons, an increase of 25 per cent. over 1920. Most of this borax was shipped to France and England.

The Argentine deposits are in the provinces of Los Andes, Jujuy, Salta and Catamarca. Those worked commercially contain 25 to 40 per cent. of boric acid. The sun-dried product runs 38 to 50 per cent. anhydrous boric acid. Lack of fuel and transportation facilities makes more extended production unprofitable.

Italy.—Recent production figures for the sassolite deposits in the province of Pisa are shown in the accompanying table of world's production.

Asia Minor.—It is reported that 7483 metric tons of borax was produced from the pandermite deposits at Sultan-Chair, an increase of 10 per cent. over 1920.

WORLD'S PRODUCTION OF BORAX MATERIALS
(In metric tons)

Year.	United States.	Chile.	Peru.	Argentine.	Italy.	Asia Minor.
1913	52,600(a)	50,225(b)	2,001(b)	933(b)	2,410(d)	.....
1914	50,609(a)	31,907(b)	1,263(b)	613(b)	2,537(d)	.....
1915	60,785(a)	15,899(c)	648(c)	192(c)	2,497(d)	.....
1916	93,918(a)	13,023(c)	1,302(c)	86(c)	2,293(d)	.....
1917	98,771(a)	8,919(c)	306(c)	.....	2,335(d)	.....
1918	80,735(a)	7,482(c)	528(c)	779(c)	2,210(d)	.....
1919	60,007(a)	9,959(c)	518(c)	1,971(c)	2,063(d)	6,929(c)
1920	109,154(a)	16,754(c)	263(c)	1,687(c)	1,719(d)	6,783(c)
1921	45,000(a)	16,967(c)	410(c)	2,119(c)	2,490(d)	7,483(c)

(a) U. S. Geol. Surv. (b) Imperial Mineral Resources Bureau, London. (c) Authoritative private information. (d) Ministero di Agricoltura, Rome.

Borax Consolidated exploits the mines of Sultan-Chair. Before the war large shipments were made to Germany, France, and England, but

[1] Hoyt S. Gale, *Min. Sci. Press*, Dec. 24, 1921.

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conditions have changed since the armistice. Quotations were $50 per ton f.o.b. Constantinople in 1919 and 1920.

India.—No production data for the tincal deposits in Tibet and Kashmir are available. Most of this product, however, is consumed locally.

Markets and Prices

The European quotation in 1921 averaged £33.10 per long ton of borax, although dropping to £31 during the second half of the year.

The New York quotations for 1921 averaged 5.71 cts. per lb. for crystals in bags in car lots; during the second half of 1921 this dropped to 5.25 cts. These prices may be compared with averages of 7.75 cts. in 1920 and 7.25 cts. in 1919.

Tariff events during the year included a proposed increase of that on boric acid from ¾ ct. per lb. in the Underwood schedule to 2 cts. per lb. in the Fordney measure of July 21, 1921.

It is estimated that the world's consumption of borax and boric acid, in tons of 2000 lb., is as follows:[1]

	Tons.
United States	40,000
Japan	2,000
England (pre-war)	14,000
Canada	8,000
Germany (pre-war)	28,000
(present)	8,000
France	8,500
Other countries	25,000

[1] Private communication, F. M. Smith.

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BROMINE AND IODINE

By A. T. Ward

Bromine

The bromine production of the United States is principally from the bitterns left after extracting salt from the brines pumped from deep wells in the States of Michigan, Ohio, and West Virginia.

The Dow Chemical Co., of Midland, Mich., produces bromides directly by an electrolytic process, seven-eighths of the domestic production of bromides coming from this source, which also accounts for more than half of the total bromine made in this country.

Bromine, as such, is produced at seven or eight plants in the Kanawha and Ohio valleys, using the acid-oxidizing process. The largest of these is that of J. Q. Dickinson & Co., of Malden, W. Va. Some of these plants have a capacity in excess of 300 lb. per day.

The bromine marketed in the United States during 1921 was 711,953 lb., a decrease of 448,631 lb. or 39 per cent. from the 1920 data. These figures include the bromine content of potassium and sodium bromides sold as such.

New York quotations during 1921 on bulk bromine continued to decline. Starting the year at 50–52 cts. per lb., they fell to 40–42 cts. in March, 27–28 cts. in September, and 23–24 cts. at the close of the year.

The Fordney tariff bill of July 21, 1921, would impose a duty of 10 cts. per lb., whereas bromine is now free. This is presumably an effort to reduce competition from German sources (Stassfurt), said to be quite keen.

MARKETED PRODUCTION OF BROMINE IN THE UNITED STATES (a)

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Pounds.			*Pounds.*	
1906	1,283,250	$165,204	1914	576,991	$203,094
1907	1,379,496	195,281	1915	855,857	856,307
1908	760,023	73,783	1916	728,520	951,932
1909	569,725	57,600	1917	895,499	492,703
1910	245,437	31,684	1918	1,727,156	970,099
1911	651,541	110,902	1919	1,854,971	1,234,969
1912	647,200	145,805	1920	1,160,584	745,381
1913	572,400	115,436	1921	711,953	172,759

a) U. S. Geological Survey.

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IODINE

By far the largest part of the world's production of iodine comes from Chile, where it is a by-product of the nitrate industry. Details of the working of the so-called iodine trust have recently been published.[1]

The industry is controlled by an association of iodine producers known as the *Combinacion de Yodo*, with headquarters in Iquique, operating under public deed or contract since 1894. The objects of the association were to regulate the production and exportation of iodine, to act as selling agents for the producers, and, more important, to enter into agreement with iodine producers elsewhere who are not members of the association so as to control supplies and prices. A further object was the study of means of increasing the iodine consumption throughout the world.

The statutes of the association provided for the making of sales agreements in Europe to last not more than 5 years on a basis of 5 per cent. commission. Furthermore, each producer was to pay a contribution not in excess of 5s. per quintal of iodine sold to cover administration costs.

A consulting body, known as the iodine subcommittee, was to be set up in London. This committee, of six members, would rule on prices and distribution of the product.

Recently objections have been voiced in Chile against the monopoly, and claims are made that the possibility of modern application of iodine to industrial processes would warrant a thorough extraction of the material and the lowering of prices to a commercial scale.[2] The present arrangement requires that all iodine contained in the ore whose extraction is not permitted by the quota assigned the plant must be thrown away and lost entirely. Statements are made that in place of the quantity of iodine now extracted and exported (something over 500 tons annually) from 10,000 to 14,000 tons could be produced if all the iodine contents of the treated ore were recovered. This is only an estimate based on the average yield, and as some ores do not contain iodine in profitable proportions, the total possible extraction is placed at a lower figure by other writers.

The advocates of free elaboration and sale of iodine base their arguments on the three following grounds: The greater revenue derived by the Government from a greatly increased exportation, even at a lower rate of duty; the possibility of using a free production of iodine and its sale at a fair profit as a means of adding to the revenues of individual producers and lowering the cost of the chief product (nitrate of soda)

[1] *Comm. Rept.*, Sept. 26, 1921.
[2] *Comm. Rept.*, Apr. 10, 1922.

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to a point which will aid in recovering the ground recently lost to artificial nitrogenous fertilizers; and the liberation of iodine from exclusive use in pharmacy on the presumption that a lower price would encourage its use for other purposes not practiced because of prohibitive cost.

Of the potential uses of iodine that have been demonstrated but are not in commercial practice, the more important are its application as a reagent in the manufacture of sulphuric acid and in the extraction of copper from low-grade ores. Patents have been taken out in the United States and in Chile and are being applied for in other countries covering the latter use, namely, a process of precipitation of copper by iodine, involving the recovery of iodine.

A proposed duty of 20 cts. per lb. on iodine (now free for both crude and refined) was included in the Fordney bill of July 21, 1921, placed before the Congress of the United States.

Quotations for resublimed iodine in New York during 1921 averaged about $3.75 per lb., declining from $3.85–$4.00 at the beginning of the year to $3.50–$3.60 at the close.

The consumption of iodine in the United States is indicated by the following importation data:

Year.	Crude and Resublimed.	
	Pounds.	Value.
1913	240,045	$525,959
1914	463,333	951,308
1915	612,926	1,332,387
1916	2,033,068	5,158,265
1917	609,641	1,363,468
1918	407,333	843,302
1919	1,254,011	2,395,969
1920	293,941	593,672
1921	646,211	1,430,664

In 1913 the exports of iodine from Chile were valued at 5,134,400 pesos (1 peso = $0.365), increasing in 1916 to 21,627,936 pesos, representing the largest amount ever exported in a single year. After the war-time demand had been supplied, the value of the exports declined and in 1921 the total export of iodine was valued at 9,991,132 pesos.

All nitrate firms in Chile are producers or possible producers of iodine. Anyone of the larger nitrate plants could produce a sufficient quantity of iodine to supply the needs of the entire world, if the Combinacion de Yodo did not restrict the production. At present the limited use of iodine prevents any increase in price being made, and with a view to increasing prices the combination has offered prizes for the discovery of new uses for it.[1]

[1] *Comm. Rept.*. May 15, 1922.

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CADMIUM

By A. T. Ward

Cadmium as a metal is used principally in the making of low-fusing alloys, such as for automatic fire-sprinklers and safety plugs for boilers; for dental alloys; for testing electric storage-batteries; for electric fuses; and in copper wire (0.5 to 1.2 per cent.). As the sulphide it is used principally in the paint, ceramic and glass industries, where its quality of permanency make it particularly valuable as a pigment.

Production During 1921.—The domestic production of cadmium during 1921 came from the following plants:[1]

Company.	Location.	Associated Plant.
American Smelting & Refining Co.	Denver, Colo.	Lead smelter (*a*)
Grasselli Chemical Co.	Cleveland, Ohio	Chemical works (*b*)
Krebs Pigment & Chemical Co.	Newport, Del.	Lithopone plant (*c*)
Midland Chemical Co.	Argo, Ill.	Lithopone plant (*c*)
Mineral Refining & Chemical Corp.	Carondelet, Mo.	Lithopone plant (*c*)
U. S. Smelting, Refining & Mining Co.	Kennet, Cal.	Electrolytic zinc plant (*d*)
U. S. Smelting, Refining & Mining Co.	Midvale, Utah	Lead smelter (*a*)

Production from: (*a*) lead-furnace bag-house fumes; (*b*) zinc lithopone residues and bag-house fumes; (*c*) lithopone residues; (*d*) tank residues.

As will be noted in the tables, the 1921 production of the metal was approximately half that in 1920, while that of the sulphide was practically double. There was a decrease in the average selling price of the metal, from $1.17 per lb. in 1920 to $0.98 in 1921, while the sulphide sold at $1.09 per lb. in 1921 against $1.16 in 1920.

PRODUCTION OF CADMIUM IN THE UNITED STATES (*a*)

Year.	Metal, Lb.	Value.	Sulphide, Lb.	Value.	Total Cadmium Content, Lb.	Total Value.
1913	54,198	$41,838	17,302	$12,136	67,650	$53,974
1914	91,409	81,205	22,723	20,241	109,076	101,446
1915	91 415	108,443	10,624	12,057	99,675	120,500
1916	135,212	210,931	22,176	27,942	152,453	238,873
1917	207,408	305,097	50,169	70,939	246,412	376,036
1918	127,164	188,203	51,702	70,315	167,440	258,518
1919	99,939	121,926	31,197	37,436	124,200	159,362
1920	129,283	151,261	32,133	37,274	154,290	188,535
1921	65,101	63,799	65,446	71,336	116,045	135,135

(*a*) U. S. Geol. Surv. Value based on sales.

[1] Cadmium in 1921, by C. E. Siebenthal and A. Stoll, *Min. Res. of the U. S.*, 1921, U. S. Geol. Surv.

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The world's production of cadmium is practically all from the United States and Germany. A little is made at electrolytic zinc plants in England. Recent production in Germany is given as follows:[1]

Year.	Cadmium Metal, Pounds.	Average Price per Pound, Marks.
1913	81,993	3.28
1914	86,000	2.97
1915	82,000	2.92
1916	128,000	4.79
1917	172,000	6.74
1918	236,000	6.31
1919	85,395	16.51
1920	45,971	45.27

TECHNOLOGY

The year showed much progress made toward the conclusion of experiments proving the commercial value of cadmium as a protective coating for metallic articles, such as hardware fixtures and trimmings, electrical apparatus and trimmings, and miscellaneous wire products, being a substitute for galvanizing. This new process[2] embodies the electroplating of the iron or steel article with cadmium and baking at a temperature (150°–200°C.) which causes the cadmium to alloy with the iron, resulting in a very non-corrosive surface. Late in 1921 this process was installed in eighteen plants and contracts were made for installations in nine more plants. This process has been applied to rustproofing locks, hardware, kitchen-cabinet and refrigerator trimmings, and automobile parts.

The great increase in the use of the wireless telephone has resulted in a large demand for Wood's fusible alloy for settings for crystal detectors for receiving sets. The composition of this alloy is approximately 13 per cent. cadmium, 48 bismuth, 26 lead, and 13 tin, while its melting point is 60°C.

W. C. Smith[3] states that copper-cadmium wire (0.5 to 1.2 per cent. Cd.), with a higher tensile strength, increased annealing temperature, greater hardness, and relatively high electrical conductivity (as compared with pure copper wire) has been successfully used for wireless aërials, long-span transmission wire and trolley wire. The future for this alloy would appear promising.

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[2] Covered by U. S. Patents Nos. 1,383,174, 1,383,175, and 1,383,176, controlled by the Udylite Process Co., of Kokomo, Ind.
[3] See accompanying bibliography.

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CEMENT

By Robert W. Lesley

If any evidence as to the permanent stability of the American Portland-cement industry were needed, it is amply furnished in the reports of the United States Geological Survey for the year 1921. The hundred-million mark long sought for in American Portland-cement production was passed by some twenty thousand barrels in 1920, and 1921, a year of general liquidation of industrial production and wages in the United States, had little if any effect upon Portland-cement production and shipments. It is interesting to realize that in shipments the total falling-off is 1.3 per cent., and so far as the demand in the United States is concerned, this is totally wiped out by the falling-off in exports of 1921—a decrease of 1,804,783 bbl.—so that the real demand of this country in a year of possibly the greatest business depression known for a generation equaled the greatest Portland-cement year ever known to the industry. It is true that in the latter months of 1921 the business boom which had existed in the earlier months in the building industry began to show symptoms of decrease, and toward November and December, owing to cancellations by contractors and dealers, as well as the abandonment of many large enterprises in the construction field, stocks began to pile up in the storehouses at the mills, and the stock on hand at the end of 1921 was the largest ever known to the trade. This large business of 1921 is attributed to a great extent to the successful development of the concrete road, the building of which went on in almost every state of the Union and caused marked increases in output of some of the commercial districts in the middle and far West. It might be naturally expected that with a year such as is above described the industry should have been largely profitable, but unfortunately in midsummer a reduction in the price of bags, in which cement is usually shipped, was made, and the charging-off at the end of the year of many millions of dollars in bag inventories caused marked decreases in anticipated profits of the various mills in the industry.

The following figures from reports of the United States Geological Survey cover the principal statistical facts of the industry:

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Table I shows the quantity and value of the principal hydraulic cements shipped from factories in the United States in the years 1919, 1920, and 1921.

TABLE I.—PRINCIPAL HYDRAULIC CEMENTS SHIPPED FROM FACTORIES IN THE UNITED STATES(a)

Class.	1919.		1920.		1921.	
	Quantity (Barrels).	Value.	Quantity (Barrels).	Value.	Quantity (Barrels).	Value.
Portland	85,612,899	$146,734,844	96,311,719	$194,439,025	95,507,147	180,778,415
Natural, Puzzolan	528,589	583,554	767,481	1,150,890	539,402	897,025
Total	86,141,488	$147,318,398	97,079,200	$195,589,915	96,046,549	$181,675,440

(a) U. S. Geol. Surv.

In Table II will be found the figures of Portland cement produced and in stock in the United States by commercial districts and by states.

Table III tells the story of Portland cement shipped in the United States by commercial districts and by states.

Table IV shows the average price per barrel of Portland cement from 1870 to 1921.

From Table V may be had information as to the fuel used in burning cement.

Table VI shows a great decrease in the imports of foreign cement. This is easily explained by the fact that owing to the great shortage of the material in 1920 several thousand barrels were imported from Canada to meet this demand and some increase also was made in imports from other countries.

Table VII shows the exports of the industry. The effect of the world's financial troubles in 1921 showed itself especially in South American markets into which for a number of years American Portland cement was finding a large field. The 1921 figures show a large decrease in exports, possibly explainable by the reason above given, and further explainable by the revival of exports from Germany, England, Belgium, and France to their old customers in South America.

The figures of consumption of Portland cement per capita show but slight decrease from 1920; the maximum was reached in 1916. The figures are as follows:

Year.	Barrels.	Year.	Barrels.
1914	0.77	1918	0.64
1915	0.83	1919	0.77
1916	0.89	1920	0.86
1917	0.84	1921	0.86

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TABLE II.—PORTLAND CEMENT PRODUCED, AND IN STOCK IN THE UNITED STATES, BY DISTRICTS, AND STATES (a)

Commercial District.	Production. Active Plants.		Quantity (Barrels).		Percentage of Change.	Stock (Barrels).		Percentage of increase
	1920	1921	1920	1921		1920 (revised)	1921	
Eastern Pennsylvania, New Jersey, and Maryland	22	22	27,137,594	25,571,726	− 6	2,241,160	3,000,486	34
New York	9	8	5,885,058	5,294,188	−10	488,209	790,056	62
Ohio, Western Pennsylvania, and West Virginia	9	10	7,988,934	9,501,895	+19	835,004	1,151,041	38
Michigan	11	11	4,891,457	5,777,533	+18	666,389	760,503	14
Illinois, Indiana, and Kentucky	11	10	16,886,831	17,050,741	+ 1	1,467,839	2,095,306	43
Virginia, Tennessee, Alabama, and Georgia	7	7	3,567,890	5,065,854	+42	224,978	374,105	66
Eastern Missouri, Iowa, and Minnesota	9	9	11,728,062	9,951,283	−15	1,199,744	1,717,969	43
Western Missouri, Nebraska, Kansas, and Oklahoma	12	11	6,967,129	6,351,747	− 9	622,378	873,734	40
Texas	5	5	2,562,208	2,668,741	+ 4	143,502	296,296	107
Colorado and Utah	5	5	2,392,741	1,860,573	−22	165,266	215,727	31
California	9	9	7,098,084	7,302,784	+ 3	441,138	561,175	27
Oregon, Washington, and Montana	8	9	2,917,257	2,444,984	−16	337,460	350,966	4
	117	115	100,023,245	98,842,049	− 1	8,833,067	12,187,364	38
California	9	9	7,098,084	7,302,784	+ 3	463,930	561,175	+ 27
Illinois	4	4	5,538,558	5,587,825	+ 1	403,640	753,954	+ 87
Indiana	6	.....	10,787,751	.....	....	1,047,960	.....	.....
Iowa	4	4	4,849,228	4,590,920	− 5	553,607	993,090	+ 79
Kansas	7	7	4,340,794	3,781,494	−13	399,059	536,971	+ 35
Michigan	11	11	4,891,457	5,777,533	+18	666,071	760,503	+ 14
Missouri	5	5	6,017,517	4,446,091	−26	571,697	641,580	+ 12
New York	9	8	5,885,058	5,294,188	−10	553,989	790,056	+ 62
Ohio	5	5	1,780,433	2,563,773	+44	197,521	238,676	+ 23
Oklahoma	3	2	1,553,652	1,631,525	+ 5	134,438	142,644	+ 33
Oregon and Washington	6	.....	2,218,905	.....	.....	247,809	.....	.....
Pennsylvania	21	22	28,269,314	27,628,598	− 2	2,388,836	3,413,359	+ 42
Texas	5	5	2,562,208	2,668,741	+ 4	143,502	296,296	+107
Utah	3	3	1,093,741	712,773	−35	105,397	139,107	+ 23
Other States (b)	19	30	13,136,545	26,855,804	....	1,063,590	2,919,953	.....
	117	115	100,023,245	98,842,049	− 1	8,941,046	12,187,364	+ 38

(a) E. F. Burchard, U. S. Geol. Surv.
(b) Alabama, Colorado, Georgia, Kentucky, Maryland, Minnesota, Montana, Nebraska, New Jersey, Tennessee, Virginia, and West Virginia.

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TABLE III.—PORTLAND CEMENT SHIPPED IN THE UNITED STATES, BY DISTRICTS AND STATES (a)

Commercial District.	Shipments.					Average Factory Price Per Barrel.	
	1920.		1921.		Percentage of Change in Quantity.		
	Quanti (Barrels).	Value.	Quantity (Barrels).	Value.		1920	1921.
Eastern Pennsylvania, New Jersey, and Maryland	26,629,217	$51,473,529	24,841,973	$44,110,573	− 7	$1.93	$1.78
New York	6,049,150	12,206,698	4,993,341	9,403,015	−18	2.02	1.88
Ohio, Western Pennsylvania, and West Virginia	7,519,129	14,623,740	9,185,858	15,947,184	+22	1.94	1.74
Michigan	4,442,455	10,939,633	5,680,156	10,300,289	+28	2.46	1.81
Illinois, Indiana, and Kentucky	15,871,121	29,762,420	16,423,356	28,468,092	+ 4	1.88	1.73
Virginia, Tennessee, Alabama, and Georgia	3,390,909	7,331,414	4,916,245	9,879,466	+45	2.16	2.01
Eastern Missouri, Iowa, and Minnesota	10,883,306	20,999,548	9,432,573	16,805,272	−13	1.93	1.78
Western Missouri, Nebraska, Kansas, and Oklahoma	6,611,565	13,971,290	6,100,391	12,503,617		2.11	2.05
Texas	2,626,130	5,898,972	2,514,045	5,902,863	− 4		2.35
Colorado and Utah	2,315,219	5,208,600	1,806,931	4,330,333	−22	2.25	2.40
California	7,064,010	15,449,645	7,180,700	16,856,258	+ 2	2.19	2.35
Oregon, Washington, and Montana	2,909,506	6,573,536	2,431,578	6,271,453	−16	2.26	2.58
	96,311,719	$194,439,025	95,507,147	$180,778,415	− 1	$2.02	$1.89
California		$15,449,645	7,180,700	$16,856,258	+ 2	$2.19	$2.35
Illinois	5,148,040	10,012,158	5,237,510	9,092,982	+ 2	1.94	1.74
Indiana	10,191,126	8,649,115				1.83	
Iowa	4,421,783	8,742,854	4,151,439	7,439,983	− 6	1.98	1.79
Kansas	4,158,399	8,649,157	3,643,582	7,253,944	−12	2.08	1.99
Michigan	4,442,455	10,939,633	5,680,156	10,300,289	+28	2.46	1.81
Missouri	5,605,952	10,980,453	4,375,712	8,034,540	−22	1.96	1.84
New York	6,049,150	12,206,698	4,993,341	9,403,015	−18	2.02	1.88
Ohio	1,670,958	3,561,490	2,518,723	4,615,492	+51	2.13	1.83
Oklahoma	1,484,698	3,284,41:	1,596,566	3,420,093	+ 8	2.21	2.14
Oregon and Washington	2,198,743	4,965,560				2.26	
Pennsylvania	27,662,116	52,632,082	26,622,367	46,881,625	− 4	1.90	1.76
Texas	2,626,130	5,898,972	2,514,045	5,902,863	− 4	2.25	2.35
Utah	1,022,639	2,314,413	683,446	1,717,191	−33	2.26	2.51
Other States (b)	12,565,520	26,152,383	26,309,560	49,860,140		2.08	
	96,311,719	$194,439,025	95,507,147	$180,778,415	− 1	$2.02	$1.89

(a) E. F. Burchard, U. S. Geol. Surv.
(b) Alabama, Colorado, Georgia, Kentucky, Maryland, Minnesota, Montana, Nebraska, New Jersey, Tennessee, Virginia, and West Virginia.

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TABLE IV.—AVERAGE PRICE PER BARREL OF PORTLAND CEMENT, 1870–1921

1870–1880	$3.00	1896	$1.57	1909	$0.813
1881	2.50	1897	1.61	1910	0.891
1882	2.01	1898	1.62	1911	0.844
1883	2.15	1899	1.43	1912	0.813
1884	2.10	1900	1.09	1913	1.005
1885–1888	1.95	1901	0.99	1914	0.927
1889	1.67	1902	1.21	1915	0.860
1890	2.09	1903	1.24	1916	1.103
1891	2.13	1904	0.88	1917	1.354
1892	2.11	1905	0.94	1918	1.596
1893	1.91	1906	1.13	1919	1.690
1894	1.73	1907	1.11	1920	2.020
1895	1.60	1908	0.85	1921	1.890

TABLE V.—STATISTICS SHOWING FUEL USED IN BURNING PORTLAND CEMENT (a)

Fuel.	1920.				1921.			
	Number of Plants.	Number of Kilns.	Barrels.	Percentage of Total.	Number of Plants.	Number of Kilns.	Barrels.	Percentage of Total.
Coal	96	629	81,265,667	81.2	92	607	80,557,675	81.5
Coal and oil	1	24	6,676,029	6.7	3	31	5,536,128	5.6
Coal and gas	1	6			1	6		
Oil	16	79	9,495,798	9.5	16	81	10,123,781	10.2
Coal, oil and gas	2	9	2,585,751	2.6	2	9	2,624,465	2.7
Natural gas	1	6			1	6		
Total	117	753	100,023,245	100.0	115	740	98,842,049	100.0

(a) U. S. Geol. Surv.

TABLE VI.—IMPORTS OF FOREIGN CEMENT, IN BARRELS OF 380 LB.

1887	1,514,095	1899	2,108,388	1911	164,670
1888	1,835,504	1900	2,386,683	1912	68,503
1889	1,740,356	1901	939,330	1913	85,470
1890	1,940,186	1902	1,963,023	1914	120,906
1891	2,988,313	1903	2,251,969	1915	42,218
1892	2,440,654	1904	968,409	1916	1,836
1893	2,674,149	1905	896,845	1917	2,323
1894	2,638,107	1906	2,273,493	1918	302
1895	2,997,395	1907	2,033,438	1919	8,454
1896	2,989,597	1908	842,121	1920	498,036
1897	2,090,924	1909	443,888	1921	121,030
1898	1,152,861	1910	306,863		

TABLE VII.—EXPORTS OF CEMENT, IN BARRELS

Year.	Quantity.	Value.	Percentage of Total.	Year.	Quantity.	Value.	Percentage of Total.
1904	774,940	$1,104,086	2.4	1913	2,964,358	$4,270,686	3.3
1905	897,686	1,387,906	2.2	1914	2,140,197	3,088,809	2.5
1906	583,299	944,886	1.1	1915	2,565,031	3,361,451	2.9
1907	900,550	1,450,841	1.7	1916	2,563,976	3,828,231	2.7
1908	846,528	1,249,229	1.6	1917	2,586,215	5,328,536	2.8
1909	1,056,922	1,417,534	1.6	1918	2,252,446	5,912,166	3.2
1910	2,475,957	3,477,981	3.2	1919	2,463,573	7,513,389	2.9
1911	3,135,409	4,632,215	3.9	1920	2,985,807	10,045,359	3.1
1912	4,215,532	6,160,341	5.1	1921	1,181,014	4,276,986	1.3

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Scientific Developments

During the year the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete held numerous meetings in connection with its work. In December the specification as tentatively drawn was discussed at six sessions of the American Society of Civil Engineers, when criticism and comment on the report were presented by engineers, contractors, and others interested in the various subjects dealt with. It is expected that during the year 1922 the specification in its tentative form will be presented for consideration to the American Society of Civil Engineers, the American Society for Testing Materials, the Concrete Institute, the Portland Cement Association, and the American Railway Engineering Association, the several engineering bodies represented upon and constituting the membership of the Joint Committee.

In the field of concrete an important contribution was made by Committee C-2 on Reinforced Concrete of the American Society for Testing Materials. It was in the shape of proposed tentative rules for the inspection of concrete and reinforced concrete work. This report, a well-considered and exhaustive one, deals with the all-essential matter of inspection, including the qualifications of the inspector as well as the character of the inspection required to secure safety and permanence in the large and growing science of concrete construction.

Through its Committee on Fire-proofing and its Committee on Concrete and Concrete Aggregates, the same society did much valuable work calculated to lead to better standards in fire-resisting construction and improved methods in the selection and use of sands and aggregates.

A matter of importance to the cement industry and engineering profession alike was the agreement concluded on the subject of specifications and tests for Portland cement, thus creating a single specification covering both commercial and governmental uses. This was followed by acceptance of the adopted standard on the part of the American Engineering Standards Committee and it is now known as American Standard Specification No. 1. To those who can look back to the early period of cement manufacture in the United States, when specifications were as many and varied as individual preferences in the matter, and who participated in the prolonged research and discussion covering the intervening time, this general acceptance of a single specification will seem an important epoch in the history and use of Portland cement in the United States.

In the manufacturing end of the industry increased prices for coal and increased freight-rates thereon have brought the fuel problem to the front rank as an economic proposition. The waste-heat boiler operating

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with the waste gases of the rotary kiln has made rapid strides during the year, and many plants in various parts of the country have made successful and profitable installations. Although originally suggested and put into operation in the later days of the last century, the first installations were not successful, but better engineering in both plants and boiler practice has made this form of waste-heat recovery a great feature of the year. The fuel engineer in the cement plant is another outcome of the desire to save coal and reduce cost. His work will be of great value to the future of the industry.

The shipment of potash from Germany and Alsace has put a stop to potash production in American cement mills which, during war times, had attained some degree of success. With potash at $300 to $400 a ton it could be produced at a fair profit with cement materials containing 1 to 2 per cent. of potash, but with the reopening of the foreign mines and reduced sea freights, prices were brought so low as to check the further development of the American industry.

Cement Activities in Foreign Fields

Brazil.—German and French technical papers commenting on the importations of Portland cement into Brazil show that in the first quarter of 1921 there were imported 46,983 metric tons. Of this Germany shipped 34 per cent., almost regaining her old preëminence in the Brazilian market, shipments amounting to about 43 per cent. of the total before the war. American shipments, which in 1920 had reached 44 per cent. of total imports, fell to 12½ per cent. in the first three months of 1921, notwithstanding a preferential tariff advantage of 20 per cent. Quotations show a large difference in favor of Germany for cement delivered in Brazil, the figure being $179 per ton as against $225 per ton for the American product.

Belgium.—Belgian production of Portland cement in 1920 amounted to 648,147 metric tons valued at 95,600,000 francs. Before the war production was about 1,500,000 tons. It is noted that owing to improvement in machinery, kilns, and other appliances the monthly capacity of many plants has been largely increased, and in some cases doubled. The Belgian Association of Portland Cement Manufacturers, 14 in all, produced during the first five months of 1921 267,941 tons. In the Tournai field, where both natural and artificial Portland cements are made, great improvements have been introduced in the form of rotary kilns of large capacity and improved grinding machinery. Toward the end of the year the Belgian Portland Cement Association, which had existed for nearly 20 years, dissolved owing to internal dissensions.

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Canada.—Production of Portland cement in Canada during 1921 showed an increase over that of the preceding year. The output for 1921 was 2,723,072 bbl. as against 2,035,594 bbl. in 1920. Ontario produced the great bulk of cement, although a number of makers in Quebec and New Brunswick reported appreciable quantities. At Owen Sound a new plant with a capacity of 3000 to 4000 bbl. per day has been erected. The cost of manufacture in Canada is somewhat less today than in 1920, but even now labor, coal, materials, and supplies are from 125 to 150 per cent. greater than in 1914.

Ceylon.—Investigation as to the Portland-cement making resources of Ceylon has been under way. The main difficulty encountered is the high price of coal, and the possibility of developing a small hydro-electric plant is being studied. There is the further interesting statement that investigation as to the suitability of cocoanut shells for fuel is under way.

China.—There are six Portland-cement plants operating in China at the present time. The daily capacity of these plants runs from 350 to 3000 bbl., and the average local price is between $6.50 and $7.50, Mexican, per bbl. of 375 lb. Ho Hong Portland Cement Co., near Singapore, Straits Settlements, has a plant thoroughly American. It uses the calcium carbonate from coral which is pried loose by Chinese coolies, loaded into barges, and towed to the plant. The plant was started by American engineers with an American chemist in charge of the laboratory. It has an output of 800 bbl. per day.

Congo.—A new Belgian company with a capital of 10,000,000 francs has been organized to build a plant at Katanga, in the Belgian Congo.

Dalmatia.—At the present time there are six cement plants in Dalmatia with a combined output of 500,000 metric tons per year. The locality is an ideal center for the industry, as the raw material not only lies close to the coast but is of very good quality. Despite the high price of coal, profits varied from 25 to 40 per cent. during 1919, the year production started. The industry is under the control of Italian capital with reports that English capitalists have begun negotiating for the purchase of some of the largest factories.

Dominican Republic.—This country shows, as is the case with most of the South American and West Indian countries, a reduction in American imports of Portland cement with an increase in imports from Germany. In 1920 the imports from Germany were valued at $3915, while in 1921 they increased to $38,322. This represented but nine months. During the same period of time United States imports fell from a valuation of $396,860 to $129,703.

England.—At a meeting of the Associated Portland Cement Manufacturers, Ltd., a set-back in the trade during 1921 was ascribed to the

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disastrous effects of the coal strike, the inability to compete in the overseas market with continental manufacturers, the latter due to depreciated currencies, and the Government change of policy regarding its housing schemes. Necessity for writing down the value of stocks also affected profits. Owing to the high cost of coal there is no immediate likelihood of the price of Portland cement receding to the pre-war figure. The above company is acquiring the works of the Kent Portland Cement Co., Ltd., this plant having cost £2,000,000. It has a capacity of 3000 tons per week. It is intended to form at an early date an Indian company to take over the cement works which the company together with the British Portland Cement Manufacturers, Ltd., is erecting in India. The British Portland Cement Co., owned by the Associated Manufacturers, showed a net profit in 1921 of £214,212 as against £323,406 in 1920.

Finland.—Finland has only two cement works. It is estimated that production in 1920 amounted to about 400,000 bbl., resulting in greatly decreased exports. The outlook for the current year indicates enough cement to more than fill home requirements, leaving a surplus to be exported.

France.—During 1921 there was a remarkable revival of the cement industry in France, especially in the northeast. The restoration of devastated provinces was the prime factor in the increased demand.

Germany.—The outstanding feature of the German Portland-cement industry has been investment of capital in excess of the actual requirements. Before the war production capacity was estimated at 12,000,000 tons, whereas actual output in 1913 amounted to only 7,500,000 tons. The productive capacity has been lowered since by the loss of 500,000 tons constituting the annual capacity of works located in territories ceded under the terms of the peace treaty, and by a further 1,750,000 tons representing the capacity of shut-down plants. Annual production is now estimated at 4,000,000 tons.

Protection against new domestic competition is afforded by government decree promulgated in 1916, prohibiting erection of new or extension of existing plants. This virtually confers a monopoly upon existing works. The German industry comprises eight main sections grouped according to the principal production centers. Prices reached a maximum in the spring of 1920 at 4061 marks, but were reduced by 661 marks in August and again by 200 marks in November. Present prices are 3616 marks for the Northern Association, 3426 marks for the Rhenish-Westphalian Association, and 3709 marks for the Southern Association. The further development of the industry depends largely upon increasing production and reducing overhead expenses.

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Guatemala.—The Novella Cement Co. has a plant in the city of Guatemala, capital of this country. Resources include a very high-grade limestone, clay, and the volcanic ash known as tufa. The last is used in place of clay, as it is nearer the mills and much easier to handle. The fuel is Mexican crude oil for cement burning and drying.

India.—A new cement works is projected in British Malaya with a capacity of 30,000 to 40,000 tons per year.

Jamaica.—The Government of Jamaica has under consideration the establishment of a cement factory and has employed experts from England to make preliminary investigations. Their first report in the matter expresses the conviction that the project under proper management would be a commercial success yielding large returns on the capital required.

Japan.—Talk of a cement combine in Japan is being renewed, though nothing definite has developed along that line. The demand for cement is good and an increase in price appears to be warranted. During 1919 the production of Portland cement reached 6,500,000 bbl., produced by about twenty companies employing 7000 laborers. During the war Japan secured a new cement market in Java, but doubt as to holding it exists.

Jugo-Slavia.—There are a number of works in this country, some employing as high as 800 hands. A large part of the domestic production is used in the country itself, though works in Belgrade shipped over 80 per cent. of its product overseas.

Mexico.—The combined production of the two leading cement plants in Mexico is equivalent to about 2400 bbl. per day. This amount is more than sufficient to take up the quantities of cement imported into that country in the last few years. Besides these plants one has recently started near Monterey, a second plant is under construction there, while a third started last year at Puebla. All these plants manufacture in strict accordance with the specifications of the American Society for Testing Materials, and the mills are equipped with the most modern American machinery, all of them being fortunate in having excellent raw materials.

Mozambique.—The new plant of the Mozambique Portland Cement Co., Ltd., at Delagoa Bay, has recently been inspected by British consulting engineers, who are very favorably impressed with the prospects of the concern. Considerable delay in the shipment of supplies and machinery has occurred. It is interesting to note that the Germans so far underbid other competitors for the mechanical equipment of the plant that the directors felt responsibility to shareholders compelled acceptance of the German tenders.

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Philippines.—The town of Naga, Island of Cebu, is now conceded as the best cement field in the Philippines, according to the Bureau of Science, Manila. Tests of raw materials point to the feasibility of a cement venture on a large scale. The proximity of coal mines will provide fuel by gravity, and it is reported that a plant will soon be erected in the locality by the National Cement Co., mostly owned by the Government.

South Africa.—The Union of South Africa now has six cement factories, none of them of very large capacity, however. The Portland Cement Co., Ltd., of Cape Town, proposes to erect a plant there with a capacity of 500,000 bags a year. The demand for cement is increasing and proposed housing plans will add to its consumption.

South America.—Special reference has been made to Brazil and the rehabilitation of the German cement trade in that country. Taking South America as a whole, imports of Portland cement from the United States show marked decline, with the exception of Bolivia. In that country the value of Portland cement imported from the United States in 1921 amounted to about $93,000 as against a little over $28,000 in 1920. The decline in the value of imports from the United States in other countries was as follows:

Country.	1920.	1921.
Argentina	$861,217	$114,472
Brazil	1,555,124	134,780
Chile	314,977	38,686
Colombia	557,012	276,034
Ecuador	85,548	21,504

Spain.—A new Portland-cement works is under construction at Bilbao.

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CHROMIUM

By Samuel H. Dolbear

The total amount of chromite produced in all parts of the world was less in 1921 than in the preceding year. New Caledonia produced over 91,000 metric tons in 1920, but it is estimated that production in 1921 will not exceed 75,000 tons. There was a slight drop in production in British South Africa. No Brazilian shipments are reported, as against about 3,500 tons in 1920. Grecian mines yielded 8,500 tons as compared with 5,300 tons in the preceding year. Canadian mines produced but little ore, although shipments amounting to over 7,500 tons were made, chiefly from stocks on hand.

United States

The United States is the largest consuming country and in 1920 imported about 80 per cent. of the world's production. A large part of the 150,000 tons brought in during the year is believed to have been placed in stock. This was due to the low prices prevailing. The average value of ore during that year, according to Edward Sampson of the U. S. Geological Survey, was $12.87 a ton, which is a strong contrast with $37.51 in 1918. The average value in 1913, prior to the war, was $9.56.

During the past year the price was lower than that of 1913, the average value being fixed at $8.01.

Imports into the United States in 1921 amounted to 81,836 long tons, as against 150,275 long tons in 1920, a drop of 46 per cent.

The large increase in importations of chromium chemicals, particularily sodium and potassium chromates, was notable. Potassium chromates brought in during 1920 amounted to 4,414 lb.; in 1921 the amount rose to 73,011 lb., while the price dropped from 61 cts. to 9 cts. a pound.

PRODUCTION OF CHROMITE IN THE UNITED STATES

Year.	Quantity, (Long Tons).	Value
1911	120	$1,629
1912	201	2,753
1913	255	2,854
1914	591	8,715
1915	3,281	36,744
1916	47,035	726,243
1917	43,725	1,049,400
1918	82,430	3,937,991
1919	5,079	129,302
1920	2,502	44,857
1921	282	2,900

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APPARENT CONSUMPTION OF CHROMITE IN THE UNITED STATES (a)

Year.	Domestic Sales.			Imports.			Apparent Supply.		
	Long Tons.	Value.	Average Value.	Long Tons.	Value.	Average Value.	Long Tons.	Value.	Average Value.
1913.....	255	$2,854	$11.19	65,180	$622,821	$9.56	65,435	$625,675	$9.56
1917.....	43,725	1,049,400	24.00	72,063	1,110,659	15.41	115,788	2,160,059	18.66
1918.....	82,430	3,955,567	47.99	100,142	2,892,825	28.89	182,572	6,848,392	37.51
1919.....	5,079	129,302	25.46	61,404	1,381,497	22.50	66,483	1,510,799	22.72
1920.....	2,502	44,857	17.93	150,275	1,921,824	12.79	152,777	1,966,681	12.87
1921.....	282	2,900	10.28	81,836	654,602	8.00	82,118	657,502	8.01

(a) *Min. Res. of the U. S.*, U. S. Geol. Surv.

CHROMATE AND BICHROMATE OF POTASH, CHROMIC ACID, AND CHROME PIGMENTS IMPORTED IN THE UNITED STATES (a)

(In pounds)

Year.	Chromate and Bichromate of Potash.		Chromic Acid.		Chrome Yellow or Green.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1913.....	18,629	$1,819	5,562	$1,100	161,153	$25,516
1914.....	31,858	2,375	9,164	1,597	154,933	24,731
1915.....	32,942	2,902	3,571	755	48,303	24,922
1916.....	459	75	*Nil.*	*Nil.*	29,495	9,492
1917.....	2,404	962	*Nil.*	*Nil.*	18,536	6,099
1918.....	20	8	9,512	1,857	37	2,420
1919.....	15,450	4,271	*Nil.*	*Nil.*	250	10
1920.....	4,414	2,690	1,100	90	70,868	38,910
1921.....	73,011	6,571	1,969	674	29,399	17,110

(a) Bur. of Foreign and Domestic Commerce.

THE PRINCIPAL SUPPLIES OF CHROME ORE (a)

(In metric tons)

	1913.	1914.	1915.	1916.	1917.	1918.(c)	1919.	1920.	1921.
Brazil.....	.....	.....	.....	.....	.....	18,141	4,877	3,451	.....
Bosnia.....	305	533	.....	.....	.....	500	500	.....	.....
Canada.....	.....	123	11,196	24,963	32,978	19,953	8,678	9,996	2,087
Cuba.....	.....	.....	.....	.....	.....	9,000	14,693	710	600
Greece.....	6,342	7,059	10,420	9,880	6,750	2,640	4,164	5,302	8,500
Guatemala.....	.....	.....	.....	.....	2,000	1,200	1,686	1,122	401
India.....	5,670	5,986	3,828	20,484	27,497	58,670	37,024	27,232	(c)3,500
Japan.....	.....	2,108	2,979	8,280	8,939	6,247	6,012	.....	.....
New Caledonia (b)..	63,370	42,000	67,000	74,115	41,892	26,000	20,000	91,536	(c)75,000
Queensland.....	.....	.....	.....	.....	768	236	.....	161	.....
Rhodesia.....	63,384	49,009	61,590	80,624	74,133	31,789	32,007	54,674	(c)50,188
Russia.....	.....	.....	.....	.....	.....	16,000	.....	.....	.....
Turkey.....	26,374	.....	.....	.....	.....	14,000	3,500	25,000	(c)10,000
United States.....	259	601	3,336	47,791	44,429	83,753	5,161	2,542	286

(a) From the official reports of the respective countries. (b) Exports, except 1914 and 1915, (c) Estimated in part.

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CHROMIC IRON IMPORTED INTO THE UNITED STATES IN LONG TONS (a)

	1917.	1918.	1919.	1920.	1921.
Cuba	17	8,821	14,461	710	600
Canada	19,012	20,949	8,941	8,491	7,554
Brazil	.....	17,854	4,800	3,451	.....
Greece	.....	.....	.....	5,302	8,104
Spain	.....	.....	3,035	40	.....
French Oceania	10,300	25,761	7,125	56,682	35,106
Australia and New Zealand	.....	15,976	13,854	(b)2,778	.....
British South Africa	4,750	521	29	(c)39,400	23,318
Portuguese Africa	37,800	8,000	4,000	11,000	.....
Turkey in Asia	.....	.....	3,500	12,760	5,822
Guatemala	179	1,193	1,659	1,122	401
Total	72,063	(d)100,142	61,404	(d)150,275	(d)82,865

(a) Statistics furnished by the Department of Commerce, Bureau of Foreign and Domestic Commerce. (b) E. J. Lavino & Co. importers, credit New Caledonia with all that listed above under French Oceania and Australia. (c) E. J. Lavino & Co., importers, credit Rhodesia with all that listed above under British South Africa and Portuguese Africa. (d) Includes other countries.

Foreign Countries

New Caledonia.—The deposits of this country have been the most productive in the world. The largest producer is the Tiebaghi mine situated at Paagoumene on the northwest coast. The total production from this mine prior to 1921 was about 725,000 metric tons. A large part of the production goes to the United States, as was the case in 1920. Out of the total shipments amounting to 91,536 tons in that year, the United States received 87,228 tons; United Kingdom 1,991; Belgium 1,676; Japan 508; and France 133 tons.

Several mines at La Coulee (near Noumea), where some 2,000 tons was ready for shipment, have been closed down. The ore from these mines has to be washed to bring it up to the grade of 50 per cent. At the Lucky Hit mine, at Plum, 12 miles from Noumea, there are some 4,500 tons of ore ready for shipment, and at the Anna Madeleine mine, situated at Carenage, Prony Bay, about 30 miles south of Noumea, there are some 2,000 tons of ore on the wharf ready for shipment. Under an agreement with the owners of the Tiebaghi mine, these two mines were closed for 15 years and have now been re-opened.

The Société Le Nickel proposes to manufacture ferrochromium as well as ferronickel at Yate, on the east coast, when its hydro-electric plant there is completed, within the next year or so.

The Vercingetorix mine, situated at Unia, on the east coast, 63 miles from Noumea, was opened in 1913, but was exhausted in 1919, by which time 60,000 tons had been extracted, having an average grade of 53 per cent. chromic oxide. Most of the ore was shipped to the United States. Several small deposits are being worked on Belep Island (Ile Art), which lies about 25 miles from the north end of New Caledonia. This ore, after washing, is of 60-per cent. grade, the highest grade in the country.[1]

[1] *Min. Jour.*, Sept. 24, 1921.

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British South Africa.—The estimated production during 1921 is 50,188 tons, a slight decrease as compared with 54,674 tons in 1920. Later figures may vary considerably from this estimate. Shipments to the United States in 1921 amounted to 23,318 long tons, a substantial decrease from 39,400 tons in 1920. Much of the ore shipped during 1920, and a part of that during 1921, was mined during the war but not shipped due to a lack of bottoms. The deposits in the Umwecke Hills have been examined and reported on by the Rhodesian Geological Survey.

Canada.—The Mutual mine in Quebec was operated early in January, 1921, but was later closed down permanently and the pumps removed. The J. V. Belanger mine was worked intermittently during the early part of the year, but was later liquidated, passing into the hands of the American Ferro Alloys Co. Shipments of ore and concentrates from Canada in 1920 amounted to 11,016 short tons. Shipments to the United States in 1921 amounted to 7554 tons, of which about 1893 tons is believed to be new production.

Other Countries.—Expansion of operation is planned in the Macri district, Asiatic Turkey. It is reported that the Jugo-Slovakian Government plans to operate mines in Bosnia and Serbia. Grecian mines operted at about average capacity during the past year.

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COAL AND COKE[1]

By Wm. A. White

As in all other lines of business, the breaking point in the coal industry came late in 1920. The downgrade followed, prices were steadily depressed, and 1921 production touched the lowest point in recent years. The only stimulating factor was the strike scare in the fall, when the rail unions threatened to tie up the transportation facilities of the country. But even this urge failed to raise bituminous coal prices from the trough, and after seven weeks of heavier output the country became so surfeited with coal that when the strike failed to materialize consumers withdrew their orders and production again hit the toboggan.

Production

The 1921 production record of American coal is equaled by few industries except the railroads in the ton-mileage they handled. Pennsylvania anthracite fields exceeded by nearly a million short tons that substantial mining year 1920, while the country's soft-coal output fell but 27 per cent. short—an estimated 407,000,000 short tons as compared with 556,000,000 tons. Even the record year 1918 exceeded 1921 by only 30 per cent. Although 1911, with 405,907,000 tons, was the worst recent year surpassed by 1921, yet the 1921 performance is so satisfactory in the face of the general and extreme business depression that it clearly demonstrates the basic character of coal.

Considered in broad geographic subdivisions we find some variations from the general production average for bituminous coal. The largest producing area, commonly described as the middle and northern Appalachian region and comprising the fields in Ohio and Pennsylvania, extending south to West Virginia and eastern Kentucky, produced in 1921, 73 per cent. of the 1920 output. The highest ratio was recorded in Illinois, Indiana and western Kentucky, where the 1921 output was 75.5 per cent. of 1920. The Rocky Mountain region recorded 73 per cent., and Washington 72.3. The Missouri Valley region, made up of the coal fields from North Dakota to Texas, showed in 1921 an output 65 per cent. of 1920.

In finer detail, however, there is a wide and discouraging disparity between the degrees of activity of individual districts, and as between single operating units there is the full range from no production in 1921 to

[1] Material on coal and coke in the United States abstracted from *Coal Age*.

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full-time operation. These differences in nearly all instances are directly attributable to competition for business, lower prices, and inability of operators employing union labor under contracts for higher wages to meet the selling prices of those employing non-union labor, whose wages were reduced during the year. The important exception, of course, was the anthracite region, where, although wages and prices were the highest on record, practically full-time operation was enjoyed. Until there shall be a substitute for anthracite for household use, demand for this fuel will not be seriously affected by price.

Union soft-coal districts in the northern and central Appalachian region—namely, central Pennsylvania, Pittsburgh, all of Ohio, Fairmont, Maryland, Kanawha and New River—suffered severe reductions in output as a result of the competition of neighboring non-union districts in the same region. Somerset, Connellsville, Logan, Winding Gulf and the fields along the Norfolk & Western, the high-volatile Kenova-Thacker field and Pocahontas, eastern Kentucky, and Virginia made up what the union districts lost. In other words, although the demand for coal from the markets reached by this large producing area was eminently satisfactory in view of the greatly depressed status of industry generally, the division of the trade was far from equitable. In some instances union mines were prostrate while non-union mines recorded the best year in their history.

Central Pennsylvania was one of the hardest hit of the union fields. Production in this district in 1921 was 67.6 per cent. of that in 1920, compared with 73 for the United States and 73 for the middle and northern Appalachian regions. The union mines in this field produced 71 per cent. of the total in 1920, or 41,302,415 tons, and the non-union mines produced 29 per cent. or 16,870,000 tons. In 1921 the union mines produced 62 per cent. of the total production, or 24,366,000 tons, while the non-union mines produced 38 per cent. or 14,934,000 tons.

If the union mines had maintained their percentage, their production for 1921 would have been 27,903,000 tons, which was 3,537,000 tons more than they did produce. The non-union mines in 1921 did 89 per cent. of their 1920 production, whereas the union mines did but 59 per cent.

A diagram portraying percentage of full-time operation and the causes limiting production is reproduced in this chapter. The data are taken from the weekly reports of the U. S. Geological Survey and reproduced through the courtesy of the Bureau of Coal Economics of the National Coal Association. The producer with a high cost consequent on high wages cannot sell his product, neither can the union miner demanding high wages sell his labor, as against other coal and labor at lower prices.

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Alabama and Tennessee, although largely non-union, made no better showing than they did in 1920. This was principally because Alabama, the larger producer, depends on a circumscribed market of which the depressed Southern iron and steel industry is the largest consumer. It was not until the end of 1921 that operators in Tennessee having agree-

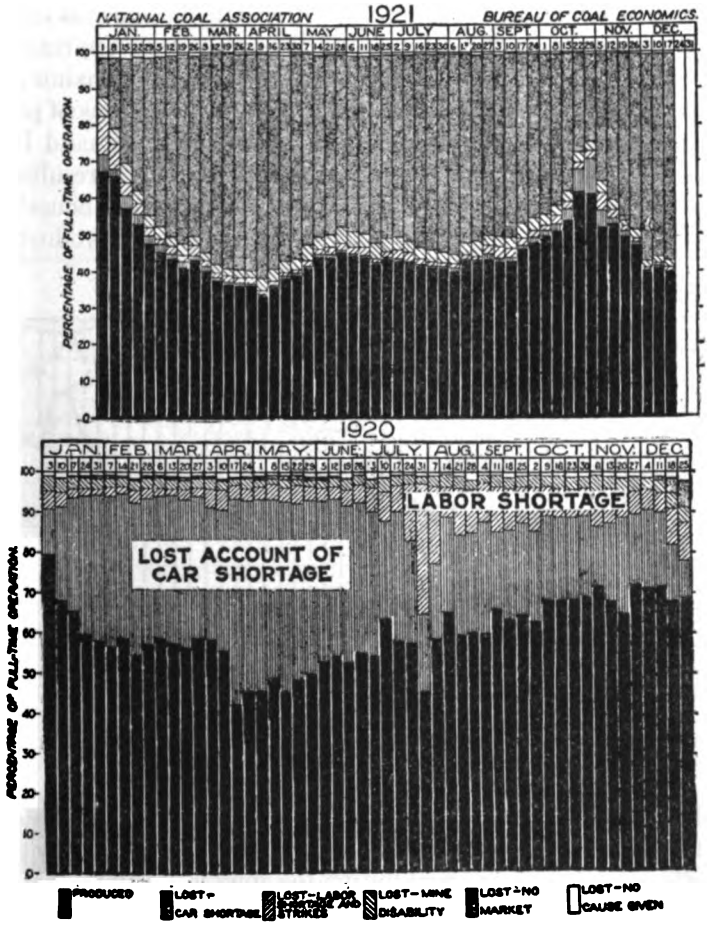

FIG. 1.—Percentage of full-time operation and time lost by causes in all United States bituminous coal mines.

ments with union miners reduced wages and were thus able to compete for a share of the going business. The important railroad fuel demand, the mainstay of the Southern fields, after iron and steel, was fair in 1921, but not sufficient to counteract the other depressing influences.

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Two factors, railroad fuel and domestic business, sustained Illinois, Indiana and western Kentucky fields and permitted a record of 75.5 per cent. of 1920, the best year, bar none, these fields as a whole ever enjoyed. In 1918 more than 60 per cent. of the output of Illinois was shipped to railroads and retail dealers and more than 50 per cent. of the output from the mines in Indiana went to the same markets. The retail trade was pursued by operators in these fields with particular vigor in 1921.

In recent years the output of Illinois has been approximately one-quarter mine-run, one-quarter screenings, and the remaining half lump, egg and nut. That is, for each ton of fine coal, two tons of prepared coal was produced. In pre-war years there was little demand for prepared sizes in the summer months and therefore screenings, a resultant product, usually were scarce. During the autumn and winter as householders and, in turn, retailers bought the domestic sizes, the by-product screenings became overabundant.

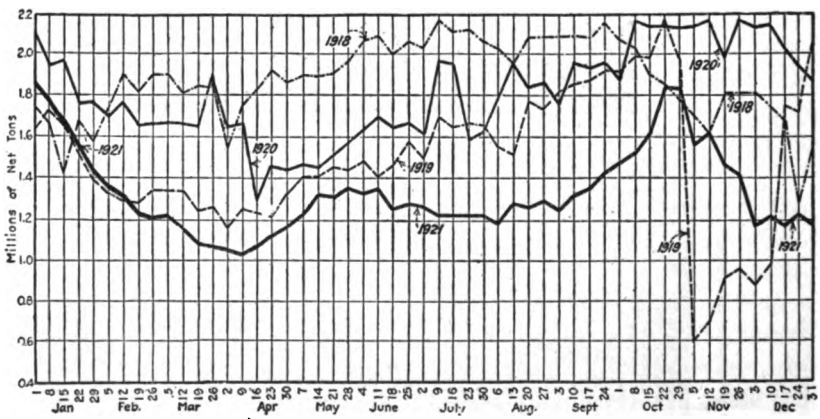

FIG. 2.—Estimated average production of United States bituminous coal per working day, 1918–1921.

In 1921 conditions were quite reversed. So hard did the operators push the sale of their domestic coal, so energetically did they promote the distribution of prepared coal during the summer of 1921, that on June 30 there was no less than 500,000 tons of unsold screenings either on the ground at the mines in Illinois or in unbilled cars on mine-tracks. This half million tons of fine coal resulted from the production of 1,000,000 tons of prepared coal that was distributed currently.

By Nov. 1 the steam market had absorbed this surplus of fine coal and thereafter screenings were in shorter supply and commanded a better price than domestic sizes. The autumn and winter market for household coal was supplied in 1921 by summer production.

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PRODUCTION OF COAL IN THE UNITED STATES IN SHORT TONS (a)

State.	1917.	1918.	1919.	1920.	1921.
	Quantity.	Quantity.	Quantity.	Quantity.	Quantity.(e)
Alabama	20,068,074	19,184,962	15,536,721	16,140,099	12,200,000
Alaska	53,955	75,606	60,674	61,111	78,000
Arkansas	2,143,579	2,227,369	1,429,020	2,050,596	1,400,000
California and Idaho	6,423	6,400	(b)	(b)	(b)
Colorado	12,483,336	12,407,571	10,323,420	12,274,225	9,130,000
Georgia and North Carolina	119,028	68,136	(c)100,036	(c)97,943	(c)75,000
Illinois	86,199,387	89,291,105	60,862,608	88,630,893	67,500,000
Indiana	26,539,329	30,678,634	20,912,288	29,090,585	19,000,000
Iowa	8,965,830	8,192,195	5,624,692	7,774,916	5,000,000
Kansas	7,184,975	7,561,947	5,224,724	5,838,408	3,600,000
Kentucky	27,807,971	31,612,617	30,036,061	35,528,762	30,000,000
Maryland	4,745,924	4,497,297	3,021,686	4,030,239	2,500,000
Michigan	1,374,805	1,464,818	996,545	1,487,765	1,150,000
Missouri	5,670,549	5,667,733	3,979,798	5,266,565	3,700,000
Montana	4,226,689	4,532,505	3,236,369	4,403,866	3,100,000
New Mexico	4,000,527	4,023,239	3,138,756	3,683,440	2,300,000
North Dakota	790,548	719,733	840,959	907,625	800,000
Ohio	40,748,734	45,812,943	35,876,682	45,032,653	32,000,000
Oklahoma	4,386,844	4,813,447	3,802,113	4,830,288	3,300,000
Oregon	28,327	13,328	(b)	(b)	(b)
Pennsylvania, bituminous	172,448,142	178,550,741	150,758,154	168,083,847	112,000,000
South Dakota	8,042	7,942	(b)	(b)	(b)
Tennessee	6,194,221	6,831,048	5,213,205	6,585,628	4,400,000
Texas	2,335,815	2,261,135	1,680,656	1,615,015	1,050,000
Utah	4,125,230	5,136,825	4,631,323	6,005,199	4,000,000
Virginia	10,087,091	10,289,808	9,326,830	11,244,106	7,800,000
Washington	4,009,902	4,082,212	2,990,447	3,753,093	2,267,000
West Virginia	86,441,667	89,935,839	79,036,553	89,450,707	71,200,000
Wyoming	8,575,619	9,438,688	7,219,738	9,623,271	7,450,000
Total bituminous	551,790,563	579,385,820	465,860,058	563,490,845	407,000,000
Pennsylvania, anthracite	99,611,811	98,826,084	88,092,201	89,598,249	90,473,451
Grand total	651,402,374	678,211,904	553,952,259	653,089,094	497,500,000

(a) U. S. Geol. Surv. (b) Included with Georgia. (c) Includes minor production from other states. (e) Estimated.

ANNUAL COAL PRODUCTION OF THE UNITED STATES
(Net tons)

Year.	Anthracite.	Bituminous.	Total.
1913	91,525,000	478,435,000	569,960,000
1914	90,821,000	422,704,000	513,525,000
1915	88,995,000	422,624,000	511,619,000
1916	87,578,000	502,282,000	589,860,000
1917	99,612,000	551,790,000	651,402,000
1918	98,826,000	579,386,000	678,212,000
1919	88,100,000	465,860,000	553,960,000
1920	89,600,000	563,490,000	653,090,000
1921[1]	90,473,000	406,963,000	497,436,000

[1] Estimated.

PRODUCTION OF BITUMINOUS COAL AND LIGNITE IN THE UNITED STATES WITH ESTIMATES FOR 1921, BY MONTHS, IN NET TONS

	1917.	1918.	1919.	1920.	1921.
January	47,967,354	42,227,000	41,487,000	48,689,000	40,270,000
February	41,352,711	43,777,000	31,566,000	40,181,000	30,851,000
March	47,868,652	48,113,000	33,719,000	46,832,000	30,392,000
April	41,854,320	46,041,000	32,164,000	37,939,000	27,553,000
May	47,086,452	50,443,000	37,547,000	38,993,000	33,330,000
June	46,824,646	51,138,000	37,054,000	45,114,000	33,896,000
July	46,291,572	54,971,000	42,698,000	45,009,000	30,385,000
August	47,372,226	55,114,000	42,883,000	48,910,000	34,538,000
September	45,107,956	51,183,000	47,402,000	49,172,000	35,127,000
October	48,337,726	52,300,000	56,243,000	52,144,000	43,733,000
November	47,689,801	43,895,000	18,688,000	51,457,000	36,020,000
December	44,037,147	40,184,000	36,612,000	52,123,000	30,868,000
Total	551,790,563	579,386,000	465,860,000	563,491,000	406,963,000

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Despite the distance of Chicago and Midwest markets from the non-union fields of eastern Kentucky and southern West Virginia, coal from these fields was poured into the West in the latter half of 1921 at a high rate and at prices low enough to attract business away from the home districts—business that had been enjoyed for several years while smokeless coal, for instance, had been diverted into the foreign markets.

Coal fields west of the Mississippi River in Iowa, the Southwest, Texas and North Dakota in 1921 recorded a decrease of 35 per cent. from 1920, lack of demand, strikes in Kansas and the competition of fuel oil and coal from east of the Mississippi River accounting for the loss.

In the Rocky Mountain region, as in the producing fields lying immediately to the east, domestic and railroad demand is the backbone of the trade, and these were less depressed than the local industrials, which in this region are base-metal smelters and the beet-sugar refiners. The principal cause of the decrease in Washington was labor trouble.

From the beginning of the year to the end of March the rate of production of bituminous coal steadily declined, making the low point of the year in the first week of April. In April and May there was a gradual recovery to a level somewhat below that in the corresponding period of 1919. Throughout the summer and early autumn the rate was variable, but within narrow limits. September and October recorded a rise in the rate of production that culminated in a peak in the last half of October, when the general railroad strike threatened. A steady drop through November brought output to the lowest level for December of any year within the past ten, save that during the first half of December, 1919, when the miners were on strike.

Consumption and Stocks

Absence during 1921 of car shortage and labor troubles as factors limiting output of bituminous coal made the rate of production a true index of demand. Both consumption and stocks of bituminous coal in the hands of consumers fluctuated in unison in 1921, though the changes were not proportionate. The first four months, January to April inclusive, were marked by a sharp drop in the rate of consumption of soft coal, from an estimated figure of 42,000,000 tons per month in October, 1920, to around 27,500,000 tons in April. The drop in consumption was reflected, of course, in a corresponding but even steeper decline in demand and consequently in production. In this period extreme uncertainty respecting coal requirements prevailed among consumers and storage coal was freely drawn upon. As a result total supplies dropped from nearly 46,000,000 tons on Jan. 1 to 38,000,000 tons on May 1.

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The evidence afforded by the statistics of production and stock clearly shows an upturn in the rate of consumption beginning with May, ascending rather rapidly until October and continuing upward at a lower angle in the last quarter of the year. Commodity loading on the railroads, railroad fuel consumption, certain lines of industrial activity such as were noticeable in paper and automobile tires, and the seasonal requirements of the country for coal all point to the correctness of this interpretation. On the other hand the rate of production of pig iron, usually considered a reliable index of both industrial activity and soft-coal consumption, marked its lowest point in July and August. This was some three months later than the low point in coal consumption.

In the five months May to September, the demand was in excess of consumption each month save July, showing a gain in consumers' storage. By Oct. 1 stocks had climbed back from the low point of April to 42,000,000 tons. The threat of a railroad strike Nov. 1 induced heavy buying of coal during October, production exceeding estimated consumption by more than 5,000,000 tons, so that on Nov. 1, according to the estimates of the Geological Survey, consumers' stocks of soft coal were more than 47,000,000 tons, topping the Jan. 1 figure by nearly 1,500,000 tons and representing a gain over April of more than 9,000,000 tons.

In the reaction that followed the removal of the strike threat, demand fell rapidly. In November production was slightly less than consumption and in December it failed by more than 6,000,000 tons of meeting actual requirements. The year 1921 therefore closed with nearly 5,000,000 tons less bituminous coal in consumer storage than when it began—that is, consumption of bituminous coal in 1921 was 5,000,000 tons in excess of production, the difference representing deflation of stocks.

While the year closed with fewer tons of coal in storage than when it opened, the consumer really was somewhat better off at the end than at the beginning, because of the reduced rate of consumption. At the going rate, 45,800,000 tons of reserve coal represented 34 days' supply, whereas 40,800,000 tons of reserve on Dec. 31 represented 35 days' supply.

The history of the past six years indicates clearly that five weeks', or 35 days', average stocks of bituminous coal for all classes of consumers in the country as a whole is the minimum below which there develops sufficient urgent demand to create an upturn in prices and, depending on the degree of depletion of reserves, a coal buyer's panic.

The Bureau of Census and the Geological Survey completed a survey of stocks of coal of Jan. 1, 1922, following their investigation in the last quarter of 1921. The following analysis presents in somewhat greater detail than the formal report the condition of the country's reserves at the close of the year.

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At the beginning of 1922 American consumers had on hand approximately 47,000,000 tons of soft coal. This was about a million tons less than the revised figure of stocks on Nov. 1. While much above the low mark of June, 1920, it was still 16,000,000 tons, or 25 per cent., below the maximum of 63,000,000 tons reached on the day of the Armistice.

In terms of days' supply the stock appears larger than it would in times of normal business. At the rate of consumption prevailing during December, the reserve was sufficient to last 41 days, if evenly distributed. On Nov. 1 a reserve of 43 days was at hand.

Were business active, the present stocks would last not more than 32 days, if evenly divided. But, of course, stocks are never evenly divided. No American city is without its share of consumers who through absence of necessary space, or sheer neglect, are without protection against interruption to supply. For this reason, as the country has learned by bitter experience, symptoms of a shortage of coal may develop in a few days if deliveries are completely stopped.

Moreover, stocks cannot be allowed to fall to zero; a certain tonnage—perhaps in the neighborhood of 20,000,000—is an indispensable minimum for steady operation of business.

Retail coal dealers' stocks of hard coal on Jan. 1 were smaller than on Nov. 1, but still much above those at any time of record in 1919 or 1920. Incomplete reports on producers' storage indicate that there had been slight increase since November, at which time yards held 1,768,000 tons of domestic sizes and 2,719,000 tons of steam sizes.

The common denominator available for comparing stocks in different localities and over different periods of time is the number of days the tonnage on hand would last at the current rate of consumption. Figures of days' supply may be misleading, however, when the rate of consumption is subnormal.

DAYS' SUPPLY OF BITUMINOUS COAL IN HANDS OF VARIOUS CLASSES OF CONSUMERS IN THE UNITED STATES, JULY 15, 1918, TO JAN. 1, 1922

(Figures represent number of days supply would last at current rate of consumption at time of stock-taking.)

	July 15, 1918.	Nov. 11, 1918.	Jan. 1, 1919.	Apr. 1, 1919.	Mar. 1, 1920.	June 1, 1920.	Jan. 1, 1921.	Apr. 1, 1921.	Aug. 1, 1921.	Nov. 1, 1921.	Jan. 1, 1922.
By-product coke plants....	28	35	32	23	15*a*	8*a*	29	28	31	38	42
Steel plants.....	27	45	42	35	9*a*	11*a*	42	38	46	46	48
Other industrials.....	48	71	65	47	27	24	64	47	56	67	51
Artificial gas plants.....	72	85	81	58	31	22	55	66	79	87	89
Electric utilities.....	39	49	49	48	21	22	44	48	44	54	51
Coal dealers, bituminous..	15	37	39	25	13	10	30	26	42	46	33
Railroads.....	25	31	32	(*b*)	11*a*	10*a*	23*a*	24*a*	(*b*)	31*a*	35*a*
Total bituminous.....	31	45	42	31	18	15	39*a*	36*a*	39*a*	43*a*	41*a*

(*a*) Estimated from incomplete data. Subject to important revision. (*b*) No data.

The figure of days' supply has the further weakness of all averages that the items going into it may vary greatly. Because industrial consumers as a group had 51 days' supply as of Jan. 1, it does not follow that

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all industrials were provided with even a week's protection against emergencies. Subject to these qualifications, the record of days' supply, by types of consumers, shown in the table, is illuminating.

Study of the table and of Fig. 3, in particular, will show that a sharply different policy was followed by the public utilities, railroads and the steel industry on the one hand, and by the retail coal trade and the general industrial consumers on the other, during the last two months of the year. The utilities, and particularly the gas works, generally added to their reserves after August. The railroads accumulated what is for them a very large supply, sufficient to last 35 days. The steel and by-product coke plants increased their stocks, both in tonnage and in days' supply, after Nov. 1. But both the retail dealers and the general industrial consumers show decreases in coal on hand from Nov. 1 to Jan. 1.

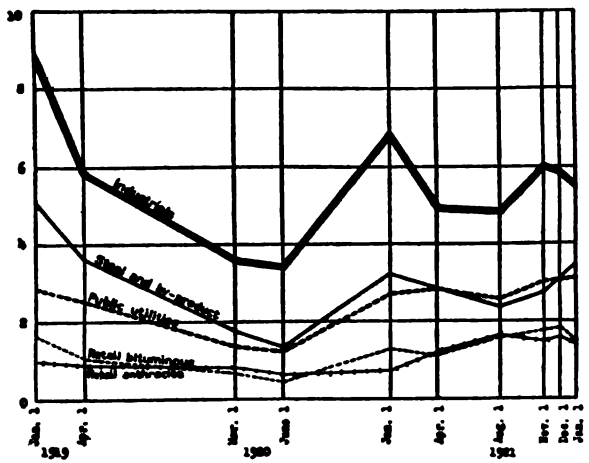

FIG. 3.—Fluctuations in tonnage of coal in storage. Lines in diagram show tons on hand at selected lists of establishments on dates mentioned. The lists are incomplete, but as the same establishments are included for the several dates the figures are comparable.

Much interest attaches to the size of these stocks, in comparison with those of Jan. 1, 1921, when reserves were comfortably large. There was an almost universal decrease during the year 1921. Only three of the 48 states reported stocks at industrial plants larger at the end of the year than at its beginning.

Like the industrial consumers, retail coal merchants reported smaller stocks on Jan. 1 than on Nov. 1, two months before. In spite of the decrease the yards of the retailers were still well stocked.

The steel industry is a good example of the way the current rate of consumption influences the apparent size of the reserve. The actual tonnage in storage at by-product coke plants and steel works increased

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from Nov. 1 to Jan. 1 by 38 per cent. But a revival of activity in the steel business so increased the current requirements that the stock in terms of days' supply increased by only 7 per cent.

Regarding anthracite, from Nov. 1 to Dec. 1 the retailers continued to fill up their stocks, and on the latter date averaged 50 days' supply. In December deliveries exceeded receipts, and the supply declined to 44 days. It was, however, considerably larger than at any time of record during 1919 or 1920.

On Nov. 1, 1921, the producers of anthracite had in storage at Eastern points a total of 4,487,671 gross tons, of which 1,768,091 tons were domestic sizes (including pea coal) and 2,719,580 tons were steam sizes.

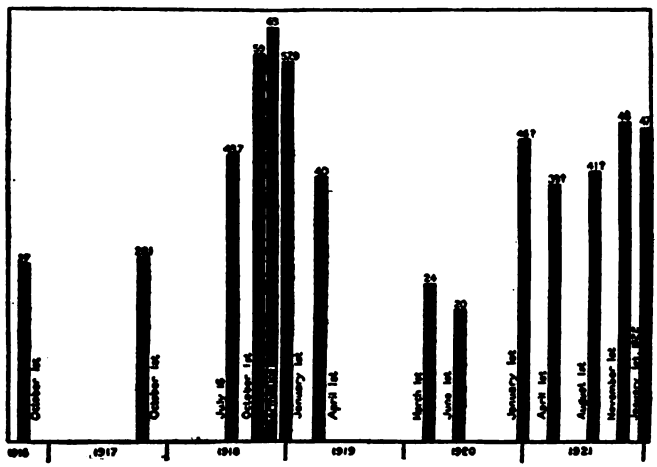

FIG. 4.—Total commercial stocks of bituminous coal in the United States, Oct. 1, 1916, to Jan. 1, 1922. Figures represent million short tons and include coal in hands of railroads, industrial consumers, public utilities, and retailers. Coal for steamship fuel, on Lake docks, and in transit is not included. Figures for 1921 and 1922 are subject to revision.

The quantity of anthracite on the Upper Lake Docks as of Jan. 1 was practically the same as Nov. 1. The Northwestern Dock Operators' Association is the authority for the following statement: Aug. 1, 1921, 1,090,258 net tons; Nov. 1, 1921, 1,316,070 tons; Jan. 1, 1922, 1,331,507 tons. The quantity of anthracite in cars at tidewater and at the rail gateways to New England as of Jan. 1 was not unusual.

The Northwestern Coal Dock Operators' Association has courteously furnished the following data showing the total bituminous tonnage on hand at commercial distributing docks on Lake Superior and Michigan: Aug. 1, 1921, 8,188,639 net tons; Nov. 1, 1921, 8,824,297 tons; Jan. 1, 1922, 7,150,654 tons. These figures are exclusive of coal on private docks of industrial concerns, such as the copper- and iron-mining com-

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panies of northern Michigan and Minnesota. The stocks of these latter companies, however, are included in the commercial storage.

About nothing have more false prophecies been made than about bituminous coal. What observer a year ago foresaw the full depth of the depression which 1921 was to reveal? Many attempting to forecast requirements at that time looked upon the depression as temporary and predicted an early revival of business.

In a year when industry is going at full speed it now requires about 550,000,000 tons to care for our domestic users of bituminous and to meet present demands for exports. How this total is divided among the principal items of the country's budget is shown in the table.

SOFT COAL CONSUMED IN UNITED STATES AND EXPORTED IN A YEAR OF ACTIVE BUSINESS(a)

	Net Tons.	Per Cent.
Railroads	153,700,000	27.7
Industrials, other than steel and coke	139,100,000	25.1
Steel plants	35,500,000	6.4
Coke:		
Beehive	36,000,000	6.5
By-product	47,740,000	8.7
Public Utilities:		
Electric	31,700,000	5.7
Coal gas (b)	4,960,000	0.9
Domestic consumers	57,100,000	10.3
Coal mine fuel	12,100,000	2.2
Exports:		
Canada and Mexico	16,500,000	3.0
Seaborne	9,500,000	1.7
Bunkers:		
Foreign trade	6,700,000	1.2
Coastwise and Lake trade	3,600,000	0.6
Total	554,200,000	100.0

(a) The figures are for the year 1917, except that the exports are the preliminary figures for 1921, and that the proportions between beehive and by-product coke are those which obtained in 1920. (b) Excludes coal consumed in by-product coke-ovens supplying gas for city use, which is included under by-product coke.

The market for American coal is overwhelmingly a domestic market, and conditions abroad can have only a subsidiary influence upon the demand for our coal. The land exports (3 per cent. of the total), the seaborne exports (1.7 per cent.), and bunker coal for ships in foreign trade (1.4 per cent.) represent the coal that leaves the country. In the aggregate this amounts to but 6.1 per cent. of the total demand. Indeed the largest element in our foreign trade—the exports to Canada—parallels closely the domestic demand, since business conditions in the two countries are similar.

Out of the 93.9 per cent. of the production which is consumed at home and therefore subject to the cycles of boom and depression in the United States itself, fully seven-tenths goes to three major classes of consumers, the railroads, the general industries and the steel industry with its satellites, beehive and by-product coke.

The railroads are still the largest customers served by the bituminous producer, absorbing 27 to 28 per cent. of his total product with surprising

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regularity. Next to the railroads comes the group of industrials other than steel and by-product plants, which includes the 340-odd manufacturing industries and the forest and mineral industries, excepting only coal mining. This group of general industrials normally absorbs a fourth of the total output—in 1917, 25.1 per cent.

What is not so generally realized is that including coal that is used as such, and the coal equivalent of the coke which finds its way into blast-furnaces, the steel industry uses almost as much coal as all other manufacturing enterprises combined. Its total annual requirements, when business is active, approximate 100,000,000 tons.

Now the demands of these three principal customers of the soft-coal producer all contract sharply at times of depression. In other words, 71 per cent. of the soft-coal demand is an elastic, unstable demand, varying markedly with the business cycle. Small wonder, then, that coal is quick to feel any change in the general tone of business, for there can be no slackening of activity in any line of industry that is not reflected in the demand for coal. A fifth of the demand is concentrated in the steel industry alone, which of all major activities is most affected by industrial depression.

There is no question but that the business depression is the cause—practically the only cause—of the 150,000,000-ton decrease in output which marked 1921. The total production was 73 per cent. of that in 1920; the total exports, 60 per cent. of 1920; the total domestic consumption, 76 per cent. of 1920.

It has been remarked that the bituminous industry was lucky to get off with a decrease of only 24 per cent. when other industries showed a more precipitate drop. But the fact is that a decrease in coal *consumption* of 24 per cent. is unprecedented in the United States. For example, after the disastrous panic of 1873 it dropped but 11.6 per cent. After 1893 it fell off still less, while in 1907 it slumped 15.8 per cent. In the dull year of 1914 it was less than in the active year of 1913 by only 11.6 per cent. In 1919 (speaking always of consumption, not production), it was but 9.8 per cent. behind 1918. A drop of 24 per cent. therefore means that so far as measured by the demand for coal, the business depression of 1921 is the most serious on record.

Wherein lay this great shrinkage in demand? As near as it can be determined it is shown in the proportions indicated in Fig. 5. The most spectacular drop was in the quantity used for beehive coke, which fell off 73 per cent. This extraordinary slump was in part accounted for by the transfer of business from beehive to by-product ovens, whose consumption fell off 34 per cent. The cut in total coal used for coke manufacture approximated 51 per cent.

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Offshore exports and foreign bunker fell to little more than half the 1920 rate. From the production of ingot steel it is estimated that the consumption of the steel industry likewise was only about half that in 1920. Locomotive fuel consumption dropped at least 17,000,000 tons, and the general industrial consumption perhaps 39,000,000 tons, or 20 per cent. Even the electric utilities, steadiest of all the consumers of coal, seemed to have taken 13 per cent. less in 1921 than in 1920, a decrease in part attributable to the substitution of fuel oil for coal.

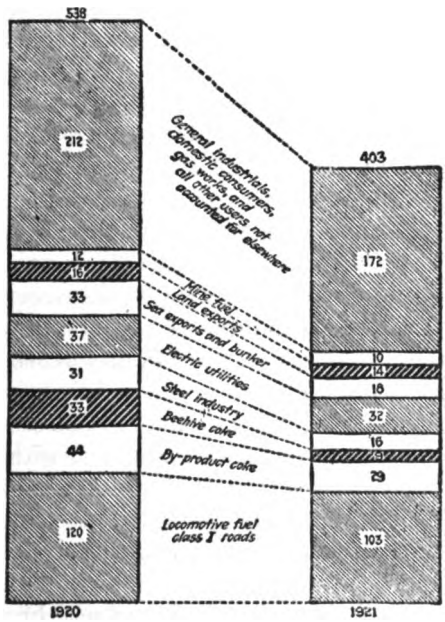

FIG. 5.—Consumption of bituminous coal, by industries, in 1920 and 1921.

The big tonnage cut came, as was to have been expected, in the items of steel, general industries and railroad fuel. Striking as was the drop in seaborne exports, it accounted for but 11,000,000 out of the total decrease of 135,000,000 tons.

DISTRIBUTION

A year with as little respect for the precedent as 1921 was certain to produce freaks in distribution as it did in production, price, and consumption. Southwest Virginia coal via Hampton Roads and southern Appalachian coal via Charleston in New York harbor, smokeless coal from southern West Virginia in Three Rivers, Quebec, by ocean up the

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St. Lawrence and by Lake down the same river simultaneously, coal from West Virginia via Lake Erie ports to Buffalo, and by-product coke from Boston to Newark, N. J., are freaks of distribution made possible by changes in previous differentials arising from high rail freights and the low mine prices on non-union coal.

Competition in 1921 threatened to upset all traditions of the trade. Hardly a consuming center but saw strange coals last year. The energy of distributors was boundless, for the spur of necessity drove them to extreme ends in the effort to market their product. In the first 8 months of the coal year—that is, from April to November inclusive—the percentage of water-borne coal into New England rose to 53 per cent., exceeded in the past 6 years only by the record of 59 per cent. in 1916–1917. The total receipts of soft coal in New England for 1921 were the lowest in the last 6 years. Shipments of bituminous coal to the Northwest via the Great Lakes in 1921 were approximately as great as in either 1919 or in 1920. The total movement of bituminous coal to tidewater fell off approximately one-third in 1921 from 1920.

The high level of freight-rates had the effect on distribution of encouraging short-haul and discouraging long-haul movements. When a community, as in part of Illinois, could obtain local coals on short hauls, these coals, though often inferior, were used in preference to better coals from more distant mines normally used.

The bituminous tidewater business of 1921 is not seen in its proper perspective if compared, in the customary manner, with the preceding year. In fact, owing to a complete reversal of conditions at the beginning of 1921, the year is as unique in its way as was the preceding year. If the statistics for the two years tell any story, it is simply that "what goes up must come down."

On the whole, however, the volume of tonnage dumped—approximately 37,000,000 net tons—is not so bad, in the light of our pre-war experience. On the other hand the pessimists may take comfort from the fact that this 37,000,000 tons represents a falling-off of about 30 per cent. from the peak set last year. However, when the complete figures for the five separate North Atlantic ports are examined, it will be found that, going back to 1919 and the war years, there has been a gain in tonnage, except perhaps at New York.

In 1920 there was the unprecedented dumping at tidewater of 53,000,000 net tons. As a result of a world shortage of fuel there was a greatly expanded export trade of 22,000,000 net tons.

A shortage of coal was the cry in New England and along the Atlantic coast, as well as inland. Nearly all steamships bunkered for the round trip or for greater steaming distances. There was a tremendous demand

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everywhere. Prices were unstable and rose rapidly. "Big production," "big prices," "big profits" was the "big" program of the industry. In short, it was a sellers' market, and a runaway market at that.

There were the newly and quickly formed export firms composed of the dollar-a-ton men who carried contracts for "millions of tons" around in their pockets. There were broken contracts and litigation, unheeded complaints about coal, mounting costs of operation, and a lot of other things. And at the end of this hectic year there was the income tax.

These are all worth thinking about in considering 1921. Were they constructive factors or destructive?

Along in the early autumn of 1920 the Eastern Gold Coast, as seen from afar in the Appalachians, began to lose some of its glitter. The ports began to fill up with coal. Prices began to shade off, soften and finally tumble. It was known as 1921 opened that the turn had come. The decline in shipments continued with slight fluctuations until April, 1921. In April there was some improvement, the total dumpings reaching 3,000,000 tons. In May the total monthly dumping had increased to 3,800,000 tons and it began to look like another 1920 at tidewater in so far as tonnage was concerned. This increase was coincident with the cessation of work by the British coal miners.

The prolonged British strike and the resulting scarcity of coal abroad made June a record-breaker in tidewater annals. A total of about 4,500,000 tons was dumped. The largest tonnage in the history of Hampton Roads was loaded in June owing to the Chesapeake & Ohio Ry. dumping the largest tonnage in its history, while Lamberts Point and Sewalls Point each contributed large tonnages to the total. The Newport News pools were well stocked with high-volatile steam and gas coals and a brisk demand from abroad developed for prompt shipment of these grades. Baltimore and Philadelphia doubled their exports during this record month.

The "carrying of coals to Newcastle" ran well into July, which showed a total dumping of 3,600,000 tons, the decrease being in exports. An interesting point about this phase of the year's business was the comparatively small effect that this sudden demand had upon prices, which continued to decline.

In August the total tonnage dumped at all ports slumped back near the 3,000,000-ton mark established during the early months of the year with a dumping of 2,500,000 tons in September, 2,800,000 in October, and again 2,500,000 tons in November, which set the pace for the close of the year.

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Of the total tonnage dumped during the year at all North Atlantic ports—approximately 37,000,000 tons—the largest amount, or about 10,500,000 tons, was delivered to local harbor points and inside the Capes, mostly at New York. About 9,000,000 tons was shipped to New England as compared with nearly 10,500,000 tons in the previous year and 8,500,000 in 1919. Total bunker requirements were approximately 8,000,000 net tons as compared with 9,000,000 in 1919. The great loss was, of course, in exports, which dropped from 22,000,000 tons in 1920 to about 9,600,000 tons in 1921. Of this, 3,000,000 tons, taken mostly from Hampton Roads, may be attributed directly to the British strike.

SUMMARY OF TIDEWATER BITUMINOUS COAL BUSINESS
(In net tons)

By Ports:	1918.	1919.	1920.	1921.
New York	17,091,000	14,234,000	14,825,000	11,912,000
Philadelphia	3,121,000	4,411,000	6,191,000	3,641,000
Baltimore	3,641,000	3,467,000	7,831,000	4,136,000
Hampton Roads	18,977,000	14,630,000	24,026,000	17,242,000
Charleston	79,000	320,000	911,000	392,000
All ports	42,909,000	37,062,000	53,784,000	37,323,000
By Destinations:				
Coastwise to New England	15,248,000	8,386,000	10,457,000	8,859,000
Exports	3,741,000	8,292,000	21,778,000	9,633,000
Bunker	6,063,000	6,874,000	9,171,000	8,135,000
Inside Capes	4,476,000	3,438,000	3,410,000	3,251,000
Other tonnage	13,381,000	10,072,000	8,968,000	7,445,000
All destinations	42,909,000	37,062,000	53,784,000	37,323,000

PRICES

Prices to the consumer and buyer, and profit to the producer and seller—taken by and large, neither was satisfactory in 1921. The consumer is convinced that his coal cost him too much. The operator has no doubt about his lack of profits. He is feverishly concerned with reducing expenses so as to exact some profit on business in a market so competitive that a few cents a ton determines a sale.

The accompanying diagram shows the relative average spot price of fourteen standard bituminous coals weighted in accordance with their normal production. Relative to the pre-war average, the spot price of these coals stood at the end of 1921 at 176, that is, 76 per cent. above the pre-war base.

For the year as a whole the relative was 201, corresponding to a weighted average price of $2.55 per net ton, or 101 per cent. over the base. This is the lowest figure since 1916, when the average price of the same coals was $1.85, or 46 per cent. above the base.

Non-union coal prices left the union coals behind in the toboggan slide in 1921. This and the constant depression of all prices throughout

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the year are the points to be particularly noted. However, because the non-union fields were more active than the union, and their prices were lower, the actual realization on total sales was below the average spot price of $2.55 noted as having been derived by weighting prices in accordance with normal output. The average realization on bituminous coal at the mine, both contract and spot, has been estimated at $3.50 per net ton for 1920. For 1921 this figure did not exceed $2.35.

It is interesting to compare the annual average of spot prices as reported weekly in *Coal Age* over the years 1913 to 1921 with the average realization for all bituminous coal in the United States as reported by the Geological Survey. The figure from the Survey is the total dollars received by all operators divided

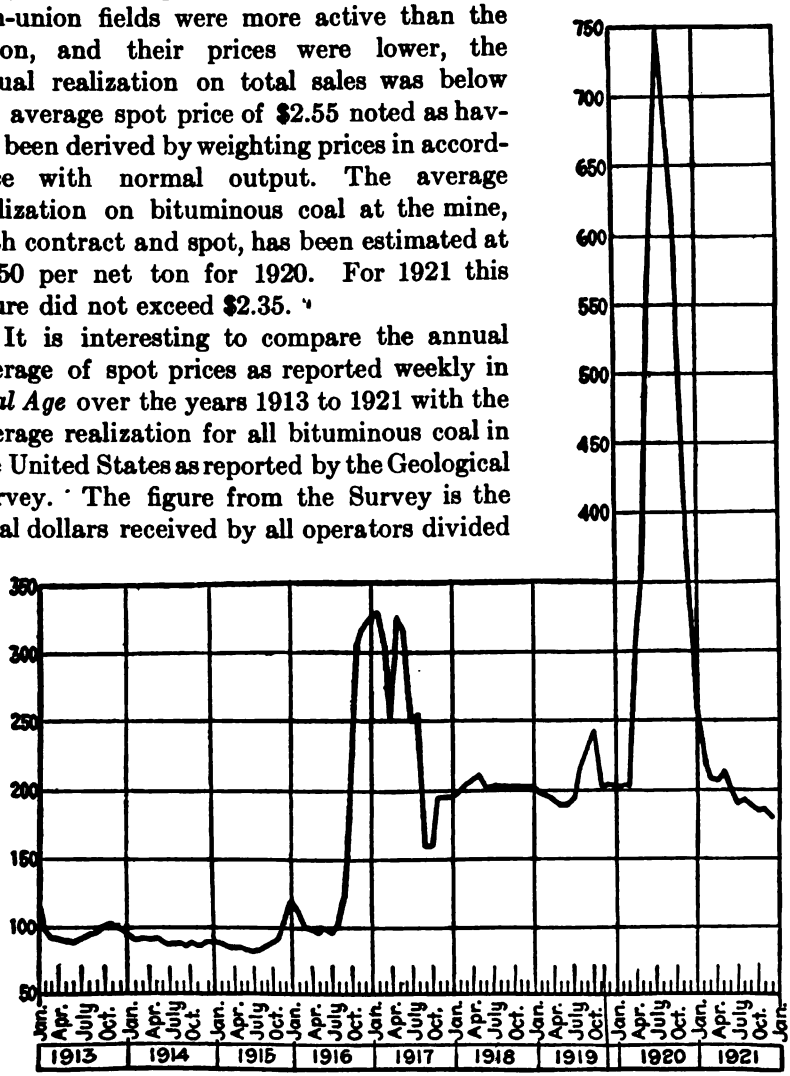

FIG. 6.—Relative spot prices of United States bituminous coal at the mines. This diagram shows the relative prices, not the actual prices. Prices for 14 coals, representative of nearly 90 per cent. of the total output of the country were weighted in accordance first with respect to the proportions of each of slack, prepared, and run-of-mine normally shipped, and second with respect to the tonnage of each normally produced. The average thus obtained was compared with the average for the 12 months ended June, 1914, as 100. The result is a series of index numbers.

by tons sold and is therefore a comprehensive reliable figure. This comparison is made in the following table:

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Year.	Average Spot Price.	Average Realized Price.	Year.	Average Spot Price.	Average Realized Price.
1913	$1.23	$1.18	1918	$2.58	$2.58
1914	1.14	1.17	1919	2.59	2.49
1915	1.12	1.13	1920	5.64	3.50(a)
1916	1.85	1.32	1921	2.55	2.35(a)
1917	3.25	2.26			

(a) Estimated.

Tonnage produced, average costs and prices received for bituminous coal, f.o.b. mines, mine-run basis, by 654 operating companies reporting to the National Coal Association, by months in 1921, according to data introduced by the National Coal Association in hearings before the Interstate Commerce Commission, Feb. 28, 1922, were as follows:

Month.	Production (Net Tons).	Total Received — Dollars.	Total Received — Average Per Ton.	Total Cost — Dollars.	Total Cost — Average Per Ton.	Margin Per Ton. (a)
January	13,760,621	$50,098,578	$3.64	$42,529,059	$3.09	$0.55
February	10,580,327	36,893,419	3.49	34,483,970	3.26	.23
March	10,505,457	35,899,329	3.42	33,971,972	3.23	.19
Total, 3 mos.	34,846,405	122,891,326	3.53	110,985,001	3.18	.35
April	9,238,059	29,457,386	3.19	30,114,706	3.26	−.07
May	11,978,174	36,613,419	3.06	34,849,555	2.91	.15
June	11,754,664	34,853,274	2.96	34,200,553	2.91	.05
July	9,946,896	29,001,018	2.92	29,877,165	3.00	−.08
August	11,384,236	32,773,861	2.88	31,825,867	2.80	.08
September	11,474,324	31,999,430	2.79	31,499,292	2.74	.05
October	14,175,260	38,734,260	2.73	36,123,188	2.55	.18
Total, 7 mos.	79,951,613	233,432,648	2.92	228,490,326	2.86	.06
Total, 10 mos.	114,798,018	356,323,974	3.10	339,475,327	2.96	.14
November (b)	10,669,823	28,499,819	2.67	29,026,626	2.72	−.05
December (c)	7,941,392	20,357,556	2.56	23,058,735	2.90	−.34
Total for year	133,409,233	405,181,349	3.04	391,560,688	2.94	.10

(a) Margin is not the same as profit. From the margin must be paid all federal income and excess profits taxes and interest on bonds and borrowed money.
(b) Six hundred and thirteen companies only.
(c) Five hundred and eleven companies only.

An indication of the course of prices in recent years, or since early in 1919, is found in the monthly summaries of costs of railroad fuel prepared by the Bureau of Statistics of the Interstate Commerce Commission. As these figures cover delivered costs and include freight where incurred, they are of course not truly representative of mine prices. The first month for which the figures are available is March, 1919, which shows an average cost of $3.45 per net ton on 8,109,000 tons of fuel coal, used by locomotives in road service. The cost declined to $3.25 in May and rose steadily to $4.80 in the last quarter of 1919. In the first quarter of 1920 the delivered cost was around $3.60 per ton, rising to $4 by November. The increase in freight-rates in August, 1920, is masked in the returns by the decline in coal prices that began the same month, but is evident in the returns for 1921, which cover in part coal bought in 1920.

The peak in coal costs for the railroads was reached in the first quarter of 1921, with an average of around $4.60 per net ton. This declined gradually to $4.20 in October, 1921. The lowest averages are, of course, in those regions where the roads originate the greater portion

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of their fuel coal. The Ohio-Indiana-Allegheny, the Pocahontas and the Central Western regions are of this character. Here coal costs in February, 1921, were $4.34, $4.38 and $3.93 respectively. In October, 1921, the regions reported $3.74, $3.78 and $3.76. The cost of railroad coal is headed downward and will decline yet more when freight-rates are reduced.

Imports and Exports

The following is a comparative statement of imports and exports of the United States for the past 4 years, in long tons:

	1918.	1919.	1920.	1921.
Imports:				
Anthracite, total	33,279	73,945	28,346	7,950
Bituminous, total	1,300,958	903,170	1,111,598	1,122,847
United Kingdom	33,390	1,884	7,403	25,651
Canada	1,250,933	825,123	1,003,485	975,118
Japan	14,214	6,617	25,364	44,813
Australia	1,369	67,503	68,234	66,050
Other countries	1,052	2,043	7,112	11,215
Coke	26,936	14,720	36,735	27,670
Exports:				
Anthracite, total	4,435,543	4,443,391	4,824,776	4,176,221
Bituminous, total	19,956,009	17,958,514	34,390,254	20,652,788
Italy	9,994	1,632,995	2,387,734	1,549,460
Canada	16,191,364	10,669,890	14,482,929	11,961,366
Panama	504,126	72,097	155,042	222,829
Mexico	162,631	101,679	203,212	172,211
Cuba	1,440,457	971,399	1,332,632	524,572
West Indies	254,501	287,744	371,560	206,781
Argentina	178,899	483,389	1,718,493	752,636
Brazil	559,099	634,109	965,019	527,225
Chile	300,062	93,618	494,121	150,844
Uruguay	228,959	194,997	267,807	88,390
Other countries	125,917	2,816,597	12,011,705	4,496,474
Total coal	24,391,552	22,401,905	39,215,030	24,829,009
Coke	1,506,986	640,139	821,252	273,888
Bunker coal	5,532,175	7,342,734	9,362,178	7,547,518

Alaska

The output of Alaska coal was about 78,000 tons in 1921 and 61,111 tons in 1920. In 1921 about 58,000 tons came from the Matanuska field, principally from the Eska mine, operated by the Alaskan Engineering Commission to supply coal for the railroad. The Navy Coal Commission continued underground exploration for coal at Chickaloon and at Coal and Moose creeks, with fairly encouraging results. The Eska mine, operated since 1917, was closed in October for the reason that there was a large stock of coal on hand. The Evans-Jones mine, near the Eska, is being systematically developed and now has a connection with the railroad. A washery for the Matanuska coal was about completed at the end of the year.

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The most significant feature of the year's coal mining is that there are now two commercial mines, the Evans-Jones and the Healy, and these mines, though only small producers, will be operated throughout the year because they have railroad transportation. Both these mines are the result of local enterprise.

The question whether the deposits of high-grade bituminous coal in the Matanuska and Bering River fields contain a large tonnage of fuel available under the present high cost of recovery and with the present market is still unanswered. There is, however, no doubt that one or both these coal fields will be able to supply the local demand. Actual mining of the lower grade of Matanuska coal has proved that it can be produced in competition with imported coal. The Alaskan Engineering Commission has during four years of operation at the Eska mine made an output of nearly 200,000 tons of coal at a cost of about $1,150,000, or $5.60 a ton. This was used in the construction of the railroad. Had the Government imported this coal, it would have cost nearly $3,000,000. This proves beyond doubt that commercial mining in at least part of the Matanuska field is feasible. Some have even gone so far as to claim that the Matanuska branch of the Alaska Railroad, which cost less than $2,500,000, has already proved a blunder. Such statements are without basis of fact, as shown by the record of mining in the Matanuska field.

ANTHRACITE [1]

Total production of anthracite gained approximately 700,000 long tons over the 1920 total, in spite of a warm and industrially depressed December. But there was a difference in favor of 1921 that this statement does not show. In 1920, owing to the shortage of bituminous coal at consuming centers during a considerable portion of the year, the demand for steam sizes of anthracite was considerably in excess of normal, as a result of which washeries and dredges were actively engaged in the recovery of steam sizes from culm banks and river channels. The business depression of 1921, which has resulted in a notable decrease in the production of bituminous coal, has also been reflected in the partial or entire suspension of washery and dredge operations.

Of the total production of anthracite a little less than 90 per cent. is shipped or sold locally, as approximately 11 per cent. is consumed annually in the operation of the collieries. The following table shows the annual production, the colliery consumption, and the commercial or marketed product for the last decade. It will be noted that in addition to the two war years there were two others, 1913 and 1914, in which the output exceeded that of 1921:

[1] E. W. Parker, Director, Anthracite Bureau of Information, *Coal Age*, Jan. 19, 1922.

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TOTAL PRODUCTION, COLLIERY CONSUMPTION, AND COMMERCIAL PRODUCTION OF ANTHRACITE
(In gross tons)

	Total Production.	Colliery Consumption.	Commercial Production.
1912	75,322,855	7,979,696	67,343,159
1913	81,718,680	8,581,694	73,136,986
1914	81,090,631	8,707,052	72,383,579
1915	79,459,876	8,925,486	70,534,390
1916	78,195,083	8,715,071	69,480,012
1917	88,939,117	9,321,965	79,617,152
1918	88,237,575	9,128,526	79,109,049
1919	78,501,931	8,576,850	69,925,081
1920	80,032,175	8,843,502	71,188,673
1921	80,779,867	8,800,000	71,979,867

The difference, economically, between anthracite and bituminous coal could hardly be more clearly set forth than by comparison of the statistics of production of these commodities. Bituminous coal is primarily an industrial fuel. In 1921 it showed a decrease in production, as compared with 1920, of one hundred and fifty million net tons, or practically 27 per cent. Anthracite, on the other hand, is primarily a domestic fuel. Its total production in 1921, for this reason, was nearer the normal mark than was the soft-coal total.

The production of steam sizes shows a decrease of some 2,000,000 tons, all of which may be assigned to the shutting-down of the washeries and dredges.

One of the interesting features of the anthracite industry during the greater part of 1921 was that the domestic sizes most in demand were stove and chestnut, the two most costly sizes, while egg coal, next highest in price, was in fair demand, and pea coal, the cheapest of the domestic grades, was at all times difficult to move and many thousands of tons were stocked in the storage yards. The steam sizes, in sympathy with bituminous coal, were in light demand throughout the year.

ANTHRACITE SHIPPED IN 1921, BY REGIONS AND SIZES(a)
(In gross tons)

Size	Lehigh Region.	Schuylkill Region.	Wyoming Region.	Sullivan County.	Total.	Percentage of Total.
Lump	*Nil.*	9,703	2,627	*Nil.*	12,330	.....
Broken	175,407	645,464	1,643,403	10,416	2,474,690	3.6
Egg	1,309,833	2,525,905	6,368,606	25,515	10,239,859	14.7
Stove	1,773,719	3,798,810	9,071,072	44,037	14,687,638	21.1
Chestnut	2,397,108	4,861,832	11,31 208	65,534	18,636,682	26.8
Pea	1,009,013	2,067,543	2,754,162	34,661	5,865,379	8.4
Buckwheat, No. 1	1,262,794	3,591,548	4,594,667	*Nil.*	9,349,009	13.4
Buckwheat, No. 2 and rice	627,763	1,245,228	2,642,663	*Nil.*	4,515,614	6.5
Buckwheat, No. 3 and barley	672,212	1,214,119	1,278,387	*Nil.*	3,164,718	4.6
Boiler	16,801	73,805	187,590	*Nil.*	278,196	0.4
Other (b)	102,595	124,211	46,119	57,523	330,448	0.5
Totals	9,357,245	20,058,168	39,891,464	237,686	69,554,563	100.0

(a) Condensed from table of U. S. Geol. Surv. (b) Includes culm, buckwheat No. 4, screenings, settlings, silt, mine-run, dirt, and slush.

Taken as a whole the anthracite trade may be said to have been "spotty" during the entire year. The coal year, beginning April 1, found most of the domestic consumers with some supplies on hand, as

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the winter of 1920–21 had been one of exceptional mildness—a typical "open winter." There was not, in consequence, any late winter or early spring buying to speak of in order to eke out the winter supply.

Market conditions were not the only difficulties with which the industry had to contend and which made the year 1921 one to be remembered. Politics played no inconsequential part among the disturbing elements, and there was an exceptionally plentiful crop of legislation, state and federal, proposed and enacted. The Governor of Pennsylvania in January in his message to the Legislature recommended legislation imposing a tax of 8 cts. a ton on anthracite and 4 cts. a ton on bitumiuous coal. This eventuated in April in the passage of what are known as the Kohler, Fowler, and Williams bills. The first imposed penalties for the causing of surface subsidence through the mining of anthracite. The second exempted from the punitive clauses of the Kohler Act those companies accepting the provisions of the Fowler Act, which acceptance included an agreement to pay an impost of 2 per cent. on the f.o.b. mine value of all coal prepared for market, for the purpose of compensating surface owners for any damage incurred and for paying the salaries and expenses of a commission to be appointed by the Governor to administer the law. Failure to signify non-acceptance of the law was interpreted as giving consent through silence. The third, or Williams Act, imposed a direct revenue tax of 1.5 per cent. on the value of the commercial output of all anthracite mined and sold. This act became effective as of July 1, and the Kohler and Fowler acts on Aug. 27.

All of the legislation enacted affected anthracite production only; bituminous mining operations were entirely overlooked by the law makers. So far as known to the writer, the provisions of the Fowler Act were not accepted by a single anthracite operating company, and rather than incur the risk of being penalized under the Kohler law a number of mines whose workings extended under the City of Scranton were closed down on the day the law became effective, such action being strongly opposed by the mine workers and by the citizens of Scranton, who had been persistently active in procuring the legislation which produced that result.

In October Judge Henry A. Fuller, of Wilkes-Barre, rendered a decision in a case coming before him in which he held the Kohler Act unconstitutional, the Fowler Act naturally falling with it. The matter has been appealed to the Supreme Court, but pending final adjudication by that tribunal, operations at the Scranton collieries were resumed on Nov. 2. A law similar in essentials to the Williams Act passed in 1913 was declared by the Supreme Court to be in violation of the State Constitution.

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Of prime interest and importance to the future of the anthracite industry were the decrees of the Supreme Court of the United States ordering definite separation of the railroad and coal-mining interests in the "Reading" and "Lehigh Valley" cases. In accordance with these decrees plans for the segregation of the properties have been submitted, but in the case of the "Reading" properties appeal has been taken because of disagreement between the preferred and common stock owners as to the manner in which they shall participate in the division.

The "Reading" decree ordered also that the Central Railroad of New Jersey, controlled by the Reading company, dispose of its holdings of stock in the Lehigh & Wilkes-Barre Coal Co., of which the Central owned 92 per cent. This sale was effected in November, a syndicate composed chiefly of First National Bank (N. Y.) interests, and Burns Brothers, being the purchaser. In line with these transactions was the sale in September of the coal-mining properties of the Delaware, Lackawanna & Western Railroad Co. to the Glen Alden Coal Mining Co.

The shipments of anthracite by months are shown in the following table, in long tons:

	1919.	1920.	1921.
January	6,066,689	5,713,319	5,740,438
February	3,951,898	4,913,664	5,966,101
March	4,016,290	6,077,821	5,737,771
April	5,326,363	4,814,211	5,967,465
May	5,817,756	6,155,878	5,793,895
June	5,737,472	6,319,957	6,031,937
July	6,189,740	6,389,100	5,462,760
August	6,241,809	6,207,653	5,575,115
September	5,786,282	3,592,954	5,519,412
October	6,671,891	6,240,901	5,872,783
November	6,066,501	5,765,347	5,314,014
December	6,251,736	6,436,320	4,635,922
Total	68,124,427	68,627,125	67,617,713

Coal Mine Fatalities

Accidents at coal mines in the United States in 1921 resulted in a smaller loss of life than in any year since 1903, according to a report compiled by the U. S.Bureau of Mines. Information received from all state mine inspectors shows a total of 1973 men killed, as compared with 2271 in the preceding year, a reduction of 298 fatalities, or more than 13 per cent. The decrease was due largely to the fact that the bituminous mines were idle much of the year, the total production representing a decrease of more than 23 per cent. below 1920.

For every million tons of coal produced the fatality rate for the past year was 3.99, while for 1920 it was 3.52. Paradoxical as it may seem, it is believed that the idleness of the mines during much of the year, while resulting in fewer lives being lost, nevertheless was partly respons:-

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ble for the increased accident ratio on the basis of production. Underground operations tend to become more hazardous during periods of idleness, because of increased likelihood of roof falls, gas accumulations, etc., as well as a lessening of the morale of the workmen, resulting in more frequent accidents when the men return to work.

Most of the fatalities were, as usual, due to falls of roof and side, and haulage accidents. The year was remarkably free from large disasters, there being but five accidents killing five or more men each, resulting in a total of 34 deaths. These deaths constituted but 1.7 per cent. of the year's total of 1973 fatalities, a lower record than for any year during the past decade.

FATALITIES AT COAL MINES IN THE UNITED STATES

	1917.	1918.	1919.	1920.	1921.
Underground:					
Falls of roof or face	1,230	1,294	1,100	1,132	1,019
Haulage	488	506	381	408	338
Gas and dust explosions	360	129	191	164	115
Explosives	110	135	206	128	152
Electricity	79	88	69	76	80
Miscellaneous	108	129	130	112	116
Shaft:					
Miscellaneous	60	52	53	56	36
Surface:					
Haulage	110	118	93	78	44
Machinery	46	40	22	29	17
All others	105	89	92	88	56
Total	2,696	2,580	2,317	2,271	1,973

[1] W. W. Adams, Statistician, U. S. Bureau of Mines.

Fuel Briquets

In company with the production of soft coal, the manufacture of fuel briquets declined sharply in 1921. The total output was 398,949 net tons, a decrease when compared with the year preceding of 168,243 tons, or 30 per cent. The total value at the plant was $3,632,301, nearly a million dollars less than in 1920. The average value per ton, however, increased from $8.15 to $9.11 per ton. All districts reported a smaller output than in 1920, but the principal decrease was in the Eastern states, where also the increase in the year preceding had been most striking. The plants in that district operate largely on anthracite fines.

It should be remembered that 1920 was a year of record production, owing to the shortage of coal which created an unusual demand for briquets. Production in 1921 compared favorably with that in other recent years, and was but 7907 tons behind 1917 and 78,286 tons behind 1918. In those years also coal was hard to obtain because large quantities were diverted from the regular trade to meet the demands of extraordinary wartime activities.

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FUEL BRIQUETS PRODUCED IN THE UNITED STATES (a)

Year.	Quantity (Net Tons).	Value.	Year.	Quantity (Net Tons).	Value.
1907	66,524	$258,426	1915	221,537	$1,035,716
1908	90,358	323,057	1916	295,155	1,445,662
1909	139,661	452,697	1917	406,856	2,233,888
1911	218,443	808,721	1918	477,235	3,212,793
1912	220,064	952,261	1919	295,734	2,301,054
1913	181,859	1,007,327	1920	567,192	4,623,831
1914	250,635	1,154,678	1921	398,949	3,632,301

(a) U. S. Geol. Surv.

With one exception, all plants which reported in 1920 were operated in 1921, and one new plant began operations. Of the 15 plants which reported, 8 used anthracite culm as the fuel constituent, 1 Arkansas semi-anthracite, 1 a mixture of anthracite culm and bituminous slack, 1 a mixture of bituminous slack and sub-bituminous coal, 2 carbon residue from the manufacture of oil gas, and 1 bituminous coal first subjected to low-temperature carbonization.

PEAT[1]

The peat industry in the United States reflected the general business depression in 1921. Many of the operators were idle during the whole year; others operated but a few months.

The quantity of peat produced in the United States in 1921 decreased 42,798 short tons, or 58 per cent.; the value decreased $661,613, or 72 per cent. Peat used in the manufacture of fertilizer decreased 33,812 tons, or 53 per cent. in quantity and $522,589, or 68 per cent., in value. Peat used in the manufacture of stock food decreased 93 per cent. in quantity and 96 per cent. in value. Only a small quantity of peat fuel was reported for 1921.

PEAT PRODUCED IN THE UNITED STATES(a)

Year.	Number of Plants Reporting.	Short Tons.	Value.	Average Price.
1916	13	52,506	$369,104	$7.03
1917	18	97,363	709,900	7.29
1918	25	107,261	1,047,243	9.76
1919	15	69,197	705,532	10.20
1920	18	73,204	921,732	12.59
1921	21	30,406	260,119	8.55

(a) U. S. Geol. Surv.

The 21 plants reporting production in 1921 were distributed as follows: New Jersey 4, New York 4, California 3, Illinois 2, and Florida, Georgia, Massachusetts, Michigan, Minnesota, New Hampshire, North Carolina, and Wisconsin 1 each. California was the largest producer, with an

[1] K. W. Cottrell, U. S. Geol. Surv.

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output of 12,672 short tons, valued at $117,580. New Jersey ranked second, with an output of 12,051 tons, valued at $94,269. Illinois ranked third.

Coke in the United States

It was shown conclusively in 1921, according to the United States Geological Survey, that by-product coking of bituminous coal is continuing to supersede beehive coking. This change in practice has been in progress for some years, but the first convincing demonstration that the by-product branch of the coking industry could maintain itself in a period of industrial depression more strongly than the beehive branch was made in 1921.

In 1921 the output of by-product coke was almost 20,000,000 short tons, and that of beehive coke was about 5,500,000 tons, figures that show a striking contrast with those for 1920, when the output of by-product coke was more than 30,000,000 tons and that of beehive coke was more than 20,000,000 tons.

The output of beehive coke in 1921 was less than that in any other year since 1885. One month of the year showed an output of only one-ninth the average monthly output in 1920. The monthly average for 1921 was only about 27 per cent. of that for 1920.

The output of by-product coke in 1921 also showed a marked decline from that of 1920, though the output in the minimum month was more than half of that in the average month of the preceding year, and the output for the entire year was practically two-thirds that in 1920. This comparison of 1921 with 1920 becomes still more striking if we remember that 1920 was easily the banner year in the production of by-product coke in the United States. In other words, despite the extraordinary slump in business, which greatly lowered the output of by-product coke, it was greater in 1921 than in any preceding year except 1917, 1918, 1919, and 1920.

The continuance of the activity in by-product coking during a period when business was subnormal may have been due in part to the economic superiority of the by-product ovens over the beehive ovens, but it is in part due to the fact that many by-product coke-oven plants require elaborate organization and represent large investments and must therefore be kept active in order to preserve the working force intact and prevent the undue deterioration of the plants. The loss due to the operation of such plants at less than a normal profit is smaller than that which would be incurred if they were allowed to remain idle and thus to make immense investments wholly unproductive. Furthermore, the gas produced at many by-product coke-oven plants is sold under contract to

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public-utility companies that supply gas to near-by communities, so that the discontinuance of the operation of the by-product plant would constitute a violation of its contract with the public-utility company. In view of these facts the greater production reported by the by-product coke industry in 1921 can not be considered a measure of the relative cost of production in beehive and by-product ovens.

COKE PRODUCTION IN THE UNITED STATES

	Beehive, Net Tons.	By-product, Net Tons.	Total, Net Tons.
1893	9,464,730	12,850	9,477,580
1900	19,457,621	1,075,717	20,533,348
1910	34,570,076	7,138,734	41,708,810
1915	27,508,255	14,072,895	41,581,150
1916	35,464,224	19,069,361	54,533,585
1917	33,167,548	22,439,280	55,606,828
1918	30,480,605	25,997,580	56,478,185
1919	19,650,000	25,143,542	44,793,542
1920	20,511,000	30,833,951	51,344,951
1921 (preliminary figures)	5,561,000	19,918,000	25,479,000

PRODUCTION OF BY-PRODUCT COKE BY STATES (a)
(In net tons, excluding screenings and breeze)

tate.	1918.	1919.	1920.	1921.
Alabama	2,634,451	2,230,933	3,123,890	2,406,000
Colorado	230,663	412,863	(b)	(b)
Illinois	2,285,610	1,703,903	2,136,793	1,326,000
Indiana	3,898,215	3,702,180	4,553,607	3,030,000
Kentucky	517,749	408,278	466,985	186,000
Maryland	474,368	356,237	682,132	293,000
Massachusetts	556,397	393,331	488,089	318,000
Michigan	(a)	(a)	1,393,445	778,000
Minnesota	784,065	586,094	674,801	431,000
New Jersey	682,148	788,465	725,571	745,000
New York	1,069,587	751,067	1,040,192	815,000
Ohio	5,226,334	5,374,027	5,614,877	2,964,000
Pennsylvania	4,586,981	5,872,762	7,730,256	5,439,000
Tennessee	124,469	104,749	139,121	58,000
Washington	30,129	26,547	26,284	21,000
West Virginia	603,393	392,812	447,392	184,000
Combined states	2,293,021	2,039,294	1,590,426	924,000
Total	25,997,580	25,143,542	30,833,951	19,918,000

(a) Prepared by F. G. Tryon, U. S. Geol. Surv. (b) Included in combined states.

BY-PRODUCT OVENS IN USE AT BEGINNING AND END OF 1921 AND UNDER CONSTRUCTION JAN. 1, 1922, BY TYPES (a)

Type.	In Existence Jan. 1, 1921.	In Existence Jan. 1, 1922.	Under Construction Jan. 1, 1922.
Koppers	6,036	6,303	85
Semet-Solvay	2,415	2,463	.....
United-Otto	1,513	1,413	.....
Rothberg	282	282	.....
Wilputte	206	206	.....
Cambria-Belgian	250	310	.....
Gas Machinery	33	33	.....
Klönne	42	42	.....
Roberts	104	104	.....
Piette	.....	8	.....
Total	10,881	11,164	85

(a) U. S. Geol. Surv.

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BY-PRODUCTS OBTAINED FROM COKE-OVEN OPERATIONS IN 1920 AND 1921

Product.	Unit.	1920.				1921.
		Production.	Sales.			Estimated Production.(a)
			Quantity.	Value.	Average Value.	
Tar	Gallons	360,664,124	174,363,696	$6,378,040	$0.037	233,000,000
Ammonia						
Sulphate	Pounds	675,816,486	626,013,975	27,110,260	0.043	.....
Anhydrous or free ammonia (b)	Pounds	65,777,259	62,076,772	8,585,173	0.138	.....
Sulphate equivalent	Pounds	(938,925,522)	(874,321,063)	35,695,433	0.041	607,000,000
Gas:						
Distributed through city mains	1000 cu. ft.	476,485,744	53,220,824	15,716,888	0.295	308,000,000
Used in steel or affiliated plant	1000 cu. ft.		151,764,807	14,301,095	0.094	
Used under boilers, etc	1000 cu. ft.		25,430,288	2,216,335	0.087	
				32,234,318	0.140	
Light oil and derivatives:						
Crude light oil (c)	Gallons	109,709,915	1,067,045	126,158	0.118	71,000,000
Benzol: Crude	Gallons	8,747,572	1,510,420	401,296	0.266	.....
Refined	Gallons	16,977,556	15,720,356	4,096,527	0.260	.....
Motor fuel (d)	Gallons	57,645,462	55,764,265	12,644,931	0.227	.....
Toluol: Crude	Gallons	287,142	.....	.....	.....	.....
Refined	Gallons	2,710,649	2,470,364	740,722	0.300	.....
Solvent naphtha	Gallons	5,678,525	4,695,464	851,048	0.181	.....
Naphthalene: Crude	Pounds	11,246,807	11,507,703	307,999	0.027	.....
Refined	Pounds	2,921,282	2,941,059	179,975	0.061	.....
				19,348,656		
Other products (e)	.....	.....	.....	36,317	.....	.....
				$93,692,764(f)	.....	.....

(a) Estimated by assuming that the quantity of the several by-products obtained bore the same relation to the known production of coke in 1921 as in 1920. The recoveries per ton of coal charged in 1920 were as follows: Ammonia (sulphate or equivalent, 21.4 lb.; tar, 3.2 gallons; crude light oil, 2.7 gal.; gas, 10.8 M. cu. ft. (b) Mostly ammoniacal liquor, reported in content of NH_3. (c) The quantity of crude light oil refined by the producer amounted to 106,564,417 gal. (d) The benzol content of motor fuel ranged from 50 to 100 per cent. (e) Includes coal-tar oil, crude heavy solvent carbon, and pyridin oil. (f) Exclusive of coke breeze, of which 2,460,835 tons was produced and 563,019 tons was sold at a value of $1,249,004.

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NEW BY-PRODUCT OVENS COMPLETED AND PUT IN OPERATION IN 1921 (a)

Operator and Location of Plant.	Number and Type of Ovens.
New plants:	
Chicago By-product Coke Co., Chicago, Ill.	100 Koppers
St. Louis Coke & Chemical Co., Granite City, Il.	80 Roberts
Additions to existing plants:	
Woodward Iron Co., Woodward, Ala.	20 Koppers
Bethlehem Steel Co., Sparrows Point, Md.	60 Koppers
Laclede Gas Light Co., St. Louis, Mo.	8 Piette
Camden Coke Co., Camden, N. J.	37 Koppers
Cambria Steel Co., Johnstown, Pa.	88 Semet-Solvay 60 Cambria
Milwaukee Coke & Gas Co., Milwaukee, Wis.	50 Koppers
Total	503

(a) U. S. Geol. Surv.

Panama Canal Coal Shipments

During 1921 Panama Canal shipments of coal totaled 539,351 gross tons, all westbound. Of this, 139,067 tons came from the British Isles and 392,179 tons from the United States. The largest receiving section for this coal was the west coast of South America, which took 255,549 tons; Australia followed with 142,605 tons.

World Production

World production of coal in 1921 dropped back to the level of 1909. In comparison with the feverish year 1920, the year just closed shows a decrease of nearly 200,000,000 tons. The chief factors in the decrease were the British miners' strike which lasted from April to June, and—more important—a worldwide industrial depression. Prices collapsed early in the year, and the seaborne coal trade of the world fell off sharply. The consequent reduction in the volume of business offered to the shipping of the world has been an important element in the decline in ocean freight-rates, so keenly felt by American shipping.

THE WORLD'S PRODUCTION OF COAL, 1910–1921
(In metric tons)

Year.	Production (in Part Estimated).	Per Cent. Produced by United States.
1910	1,160,000,000	39.2
1911	1,189,000,000	37.9
1912	1,249,000,000	38.8
1913	1,341,000,000	38.5
1914	1,208,000,000	38.5
1915	1,190,000,000	40.5
1916	1,257,000,000	42.7
1917	1,325,000,000	44.6
1918	1,332,000,000	46.4
1919	1,168,000,000	43.1
1920	1,317,000,000	45.4
1921	1,120,000,000	40.0

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THE WORLD'S PRODUCTION OF COAL
(In metric tons)

Country	1919.	1920.	1921.
North America:			
Canada: Coal	9,756,019	11,812,871	10,636,471
Lignite	2,655,309	3,275,304	2,918,991
Greenland	2,160	2,308	2,200
Mexico	693,866	(a)	(a)
United States: Anthracite	79,915,483	82,282,000	79,400,000
Bituminous, Lignite	422,618,927	515,886,000	369,200,000
South America:			
Argentina	(a)	(a)	(a)
Brasil	(a)	(a)	(a)
Chile	1,334,789	1,060,585	(a)
Colombia	(a)	(a)	(a)
Peru	330,227	361,075	(a)
Venesuela	33,287	30,377	(a)
Europe:			
Austria: Coal	90,472	132,864	137,470
Lignite	2,006,773	2,408,865	2,398,284
Belgium	18,482,880	22,388,770	21,807,160
Bulgaria	577,739	757,250	750,000
Czecho-Slovakia: Coal	9,865,605	11,143,221	11,648,399
Lignite	17,081,298	19,943,258	21,050,712
France: Coal	21,546,000	24,300,000	28,240,887
Lignite	895,000	1,000,000	735,608
Germany: Coal	(b)116,707,200	(b)140,757,433	(b)145,610,000
Lignite	93,645,500	111,634,000	123,011,000
Greece	182,951	182,880	134,000
Hungary	3,901,720	4,963,060	6,043,745
Iceland	390	.....	.....
Italy: Coal (c)	111,151	151,862	111,400
Lignite (c)	1,129,197	1,571,735	1,019,700
Jugo-Slavia	2,497,394	3,224,324	(a)
Netherlands: Coal (d)	3,540,064	4,115,629	4,167,960
Lignite	1,881,962	1,395,851	122,000
Norway	(a)	(a)	(a)
Poland	6,262,636	6,660,145	7,842,553
Portugal	146,341	169,165	(a)
Rumania	1,540,598	1,505,184	(a)
Russia	6,463,060	6,162,000	9,851,000
Spain: Coal	5,703,637	5,420,704	5,011,429
Lignite	539,872	552,425	408,684
Spitsbergen (e)	88,776	(e)120,000	(a)
Sweden	429,267	439,584	(a)
Switzerland	64,902	74,590	10,714
United Kingdom	233,467,478	233,216,222	166,992,000
Asia:			
British India	22,991,217	17,356,889	18,659,513
China	18,292,252	19,484,896	(a)
Chosen	223,078	(a)	(a)
Federated Malay States	194,363	251,896	(a)
Indo-China	665,149	700,267	(a)
Japan (g)	32,703,338	30,819,898	24,500,000
Russia	1,836,000	1,537,000	2,384,100
Turkey	481,331	(f)700,000	(a)
Africa:			
Algeria	7,419	7,793	(a)
Nigeria	140,057	183,013	(a)
Rhodesia	462,698	524,796	521,404
Tunis	36,551	31,000	(a)
Union of South Africa	9,313,232	10,408,497	10,331,886
Oceanica:			
Australia	10,736,321	13,176,426	13,073,845
British Borneo	(a)	(a)	(a)
Dutch East Indies	949,379	1,095,718	830,000
New Zealand	1,877,506	1,873,296	(a)
Philippine Islands	32,892	58,888	(a)
Totals	1,168,000,000	1,317,000,000	1,120,000,000

(a) Estimate included in total. (b) Includes Saar Basin. (c) Includes new provinces. (d) Includes slack. (e) Shipments to Norway and Sweden. (f) Estimate based on incomplete data (g) Including Taiwan and Karafuto.

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Of the major coal-producing nations, France and Germany were the only ones to show an increase. Progress in restoring the ruined mines of France is indicated by the steady increase in output of the past three years. In 1919, 22,000,000 tons was produced; in 1920, 25,000,000; in 1921, approximately 29,000,000. A further increase of about 12,000,000 tons, however, would be necessary to bring French production up to the level of 1913. German production of bituminous coal also is still far below the pre-war level, although an increase was effected in 1921 as against 1920. German production of lignite in 1921 reached the highest point ever attained. The estimated output of 123,000,000 tons is an increase of 36,000,000 tons over the last year before the war.

The proportion contributed by the United States was 40.0 per cent., a larger share than in the years before the European war, but the smallest in any year since 1916.

Coal and Coke in Foreign Countries

Austria.[1]—In spite of the upheavals in the economic life of Austria, during the year 1921 conditions in the mining industry were comparatively satisfactory. The output of coal and lignite amounted to about 2,600,000 metric tons, an increase of 8 per cent. as compared with 1920. The removal of Government control was of great importance to the coal mines. In the summer the competition of the Bohemian lignite was severely felt, and many mines were in danger of closing down. The selling price of coal increased eightfold during the year. The Wolfsegg-Traunthal Coal Mining Co. developed rapidly, and, although the number of miners declined, the output was larger than in 1920. The rise of the currency in Czecho-Slovakia crippled the export activities of the industries and so decreased the demand for Austrian lignite.

Silesia continues to be Austria's most important foreign source of supply of coal. Private parties are now permitted to import and store coal under Government supervision, whereas heretofore coal was handled solely through the coal controller. Due to increased production in Czecho-Slovakia and Germany, more coal is now being procured for Austria from those countries.

Belgium.[2]—The Belgian fuel market during the latter part of 1921 was characterized by severe competition with Scotch and British industrial and domestic coals entering the country at low prices, an increased demand for picked domestic coals owing to abnormally cold weather, and at the end of the quarter a slight decrease in mine stocks arising from the gradual improvement of the industrial situation. A certain

[1] *Coll. Guard.*
[2] *Comm. Rept.*, Mar. 20, 1922.

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degree of over-production resulted in some increase in part-time work in the mines during September and October.

COAL PRODUCTION OF BELGIUM
(Metric tons)

	Mons.	Centre.	Charleroi.	Namur.	Liége.	Limbourg.	Total.
1913	4,406,550	3,458,640	8,148,020	829,900	5,998,480	.....	22,841,590
1914	3,578,840	2,701,550	5,764,410	534,180	4,135,070	.....	16,714,050
1915	3,310,200	2,573,430	3,875,690	410,660	4,007,520	.....	14,177,500
1916	3,705,540	3,212,860	5,223,970	497,150	4,223,350	.....	16,862,870
1917	3,869,680	2,785,400	4,671,240	437,870	3,155,510	11,640	14,931,340
1918	3,281,720	2,559,610	4,493,630	374,440	3,112,530	65,670	13,887,600
1919	4,047,480	3,113,780	6,264,000	510,690	4,406,210	139,930	18,482,880
1920	5,027,000	3,757,000	7,315,000	605,000	5,439,000	246,000	22,388,770
1921	4,728,000	3,643,000	7,475,000	605,000	5,013,000	323,000	21,787,000

COKE PRODUCTION OF BELGIUM
(Metric tons)

	Hainaut.[1]	Liége.	Other Provinces.	Total.
1913	2,200,180	877,130	445,690	3,523,000
1914	1,406,460	595,210	?	2,001,670
1915	424,460	90,140	.....	514,600
1916	667,530	124,820	.....	792,350
1917	648,210	27,830	.....	676,040
1918	509,150	13,060	.....	522,210
1919	704,000	53,000	.....	757,000
1920	1,515,000	320,000	.....	1,835,000
1921	1,113,600	214,800	62,400	1,390,800

[1] Couchant de Mons, Centre, and Charleroi.

The monthly consumption of coal (exclusive of coke and briquets) in Belgium during 1921 was approximately 225,000 tons, or 12.5 per cent. of the extraction. The production of briquets and other compressed fuel has absorbed monthly some 10 per cent. of the total extraction, but owing to the poor market for briquets (exclusive of boulets) slightly over 50 per cent. of the December production was stocked (129,599 tons). Belgian coke-ovens absorbed monthly during the past year about 5 per cent. of the Belgian coal output. Late in 1921 an increased demand from Luxemburg and Lorraine iron furnaces caused a sudden revival in the Belgian coke market, with demand considerably exceeding production and stocks rapidly being exhausted.

Canada.[1]—The output during the 12 months ended December, 1921, amounted to 15,000,000 net tons valued at $74,273,000, or $4.97 a ton. This quantity was 88 per cent. of the amount mined during the preceding year, when the total output was 16,900,000 tons. In 1919 a total of 13,900,000 tons was raised, so that although the output in 1921 was 12 per cent. lower than in the preceding year, it was more than a million tons in excess of the 1919 production.

Alberta held the premier position among the coal-producing provinces, with an output of 5,800,000 tons. Nova Scotia followed closely

[1] Dominion Bur. of Statistics.

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with 5,700,000 tons. The output of coal from the mines of British Columbia amounted to 2,800,000 tons, while Saskatchewan mined 332,000 tons and New Brunswick 180,000 tons.

An analysis of the disposition of coal during the year show that 58.2 per cent. was shipped; 22.1 per cent. went to railroads for locomotive consumption; 7.2 per cent. was used about the colliery for power purposes; 4.2 per cent. was sold for ships' bunkers; 3.2 per cent. was put on bank; 2.6 per cent. was put on the waste-dump; 1.5 per cent. was supplied to employees for domestic consumption; 0.6 per cent. was used in the manufacture of coke at the collieries; 0.4 per cent. was used in making briquets. Included in quantities referred to in the disposition was 541,820 tons lifted from bank during the year.

OUTPUT OF COAL FOR CANADA BY KINDS AND PROVINCES

Provinces.	1919.	1920.	1921.
	Short Tons.	Short Tons.	Short Tons.
Nova Scotia:			
Bituminous	5,790,196	6,437,156	5,734,653
New Brunswick:			
Bituminous	166,377	171,685	180,358
Saskatchewan:			
Lignite	379,347	335,222	332,117
Alberta:			
Anthracite	85,579	127,513	96,964
Bituminous	2,285,957	3,419,147	2,871,919
Lignite	2,562,124	3,361,105	2,885,537
Total	4,933,660	6,907,765	5,854,420
British Columbia:			
Bituminous	2,649,516	3,095,011	2,840,870
Totals for the Dominion.			
Anthracite	85,579	127,513	96,964
Bituminous	10,892,046	13,122,999	11,627,800
Lignite	2,941,471	3,696,327	3,217,654
Grand total	13,919,096	16,946,839	14,942,418

In the period under review Canada exported nearly 2,000,000 tons of coal, or a little more than 13 per cent. of the quantity actually mined. The amount exported was only 78 per cent. of the total shipped for foreign trade in 1920, and even fell slightly below the amount exported in 1919.

Central Canada has always been dependent upon the United States for a supply of coal and data showing importations of anthracite and bituminous coal from that country are therefore of peculiar interest. Importations from the United States declined during the latter part of 1921, although a plentiful supply was at all times available, and total importa-

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tions for the year amounted to only 87 per cent. of the quantities imported in the previous year. The total imports of coal in 1921 were, however, more than 1,000,000 tons higher than in 1919. Imports of bituminous coal into the whole of Canada during 1921 amounted to 85 per cent. of the quantity imported in 1920, and in both the past two years the quantities imported have been considerably in excess of the quantities brought in during 1919. Imports of anthracite amounted to 93 per cent. of the quantity imported into Canada in 1920, when the tonnage was only slightly below the amount brought in during the preceding year. The total imports of coal into Canada during 1921 amounted to 18,102,620 short tons, of which 13,536,250 short tons was bituminous and the balance, 4,566,370 tons, was anthracite.

Czecho-Slovakia.—Production of both lignite and bituminous coal increased in 1921. The output of bituminous coal was 11,648,399 metric tons, and of lignite, 21,050,712, a total of 32,699,111, as compared with 31,086,479 tons in 1920, and 26,946,813 tons in 1919. Lignite is mined in the northwestern part of Bohemia and is exported in great quantities to Germany, via the Elbe.

Dutch East Indies.—Previous to 1918, coal mining in the Dutch East Indies was open to all, but the Amending Act of that year put a stop to the granting of concessions, the rights of exploitation being reserved to the Government. The output of the State mines in that year was 560,000 tons. This increased in 1921 to 830,000 tons, due partly to the opening up of the Boekit Assam mine. The arrangements for 1922 contemplate an output of 1,030,000 tons, equal to the total coal consumption of 1918, which rose steadily until in 1921 it reached a total of 1,490,000 tons. Imports, which in 1914 aggregated 311,000 tons and 175,000 tons in 1920, rose last year to 460,000 tons, 280,000 tons of which came from Australia.

France.—The output of coal in 1921 amounted to 28,978,495 metric tons, of which 5,365,712 tons was produced by the mines damaged during the war. It was necessary for France to import 17,661,000 tons of coal last year, 3,250,000 tons of coke, and 1,152,000 tons of briquets, these tonnages being considerably less than in 1920. The exports amounted to 2,300,000 tons.

As compared with the pre-war situation, when the supply did not meet the demand, the fact that the supply now exceeds the demand was due to under-consumption. Whereas the normal requirements of the country should be about 75,000,000 tons of fuel, only 48,400,000 tons was consumed last year.

The quantity supplied by Great Britain last year was 5,563,000 tons of coal and 22,000 tons of coke, and the activity of that country is growing more energetic every day, the more so as she is driven to export exten-

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sively. This explains why the prices of British coal have fallen so much since 1920. However, it does not seem as if further reductions can be made by the producers in Great Britain.

The Germans sent to France 5,562,000 tons of coal and 3,082,000 tons of coke, or less than provided for by the Treaty of Versailles. By artifice the prices of these products have been brought down to too low a level (50 fr. for the run-of-mine coal and 53 fr. per ton for the coke).

The Saar district supplied to France 3,448,000 tons of coal, 52,000 tons of coke, and 25,000 tons of briquets.

The French output of coke only amounted to 744,756 tons in 1921, as compared with 2,941,194 tons in 1913. The distribution of French products should have been facilitated, not that of foreign goods.

French colliery owners have lowered their costs of production by cutting down wages, and reduced their sale prices to consumers. The average output of the miner continues to fall. It was 0.520 metric ton per shift in 1921, as compared with 0.526 ton in 1920, and 0.695 ton in 1913, per worker underground and on the surface. The output of the underground worker showed a slight rise last year (0.790 against 0.730 ton), but is far below 0.978 ton, the figure in 1913.

The total production of coal in France during recent years is given below:

	Metric Tons.		Metric Tons.
1913	40,844,218	1918	25,000,000
1914	26,568,258	1919	22,476,766
1915	19,523,863	1920	25,274,304
1916	21,310,000	1921	28,978,495
1917	28,891,723		

In spite of the economic crisis the coal mines of the Saar were able to maintain their production during the course of 1921. The production was 9,336,493 metric tons for the mines operated by the State (against 9,198,714 tons in 1920) and 238,109 metric tons for the private concession of Frankenholz (against 211,719 tons in 1920).

The above results were obtained in spite of the decrease in the number of working days (278.3 in 1921 instead of 302 in 1920). The average production per working day was 34,404 tons instead of 31,160 tons in 1920. However, the number of workers increased only very slightly. The underground workers increased from 52,817 to 53,920; the surface workers decreased from 17,219 to 16,251; the workers in annexed factories increased from 1347 to 2203; the number of engineers and employees increased from 2962 to 2976.

After having decreased during the first four months, production rose rapidly, with an increase in the number of working days, beginning in May, after the British coal strike. During the last quarter of the year there was another decrease in production, but in December the production

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rose to nearly the same level as in August, during which month the production was greater than in any other month of the year.

Stocks are accumulating considerably. The total shipments in 1921 were 9,047,736 metric tons, against 9,318,485 tons in 1920. Production of coke and briquets decreased; in 1921 the production of coke was 177,386 tons, against 239,637 tons in 1920; the production of briquets in 1921 was 27,840 tons, against 33,461 tons in 1920. At the end of 1921 the stocks of coal were 684,849 tons, and the stocks of coke 3783 tons, against 163,993 and 1202 tons, respectively, at the end of 1920.

Germany.—During the closing months of 1921 the shortage of coal was an increasing embarrassment to German industry. Together with the shortage of rolling stock, the high prices of iron ore, textile fibers, and other essential raw materials, and the strictly observed 8-hour day, this has been one of the chief factors in limiting German industrial output.

The preliminary official statistics show a bituminous coal production of 136,210,000 metric tons, excluding the Saar and the Palatinate, as against 131,340,000 tons in 1920. The total coal production of the entire German Empire for the year 1913 was 190,109,400 tons and 174,875,300 tons for 1912.

Production of lignite, which has been increasingly utilized for industrial purposes during and since the war, rose from 111,880,000 metric tons during 1920 to 123,011,000 tons in 1921. In each case the Saar, the Palatinate, and Alsace-Lorraine are excluded. Coke production for the same territory was 27,921,000 tons during 1921, as compared with 25,177,000 tons in 1920.

In making estimates of the domestic supply of coal to be expected in 1922, it must be remembered that the quantities furnished by that part of Upper Silesia recently awarded to Poland are to be deducted from the above figures. This amount averages 1,820,000 tons per month. The deliveries required under the peace treaty must also be considered.

The Spa Agreement provides for a monthly delivery of 2,000,000 tons of coal to the Entente nations, and the German Reichswirtschaftministerium estimates that 21,285,000 tons was actually delivered up to Dec. 1, 1921. The Germans have agreed to make up in the future the amount which they failed to supply during the past few months.

Increasing quantities of British coal have been imported, despite the large exchange premium. It is declared that British coal up to the amount of 400,000 tons was imported via Hamburg during the first nine months of 1921. The official import figures for the three months of August, September, and October show a total of 163,515 tons of coal imported from England and 34,985 tons from Czecho-Slovakia. While

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British coal was normally used before the war in Hamburg and other parts of northern Germany, it has recently appeared in the Hanover district and even in Saxony and Thuringia.

The German coal market in 1921 bore practically no relation to the world market. The purely inland condition into which the German coal trade had been forced during the war continued to prevail during 1920 and 1921. Shortage of coal for industrial needs led to the continuation of governmental regulations of the trade and the fixing of prices by a coal commissioner (Reichskohlen-Komissar). The coal exports consisted almost entirely of compulsory deliveries for account of the Reparation Commission. Before the war 44,000,000 metric tons was exported per annum. Wholesale coal prices remained the same during 1921 up to Dec. 1, when the prices per metric ton were increased from 304 marks to 580 marks for soft and gas coal, from 370 marks to 670 marks for anthracite, and from 390 marks to 900 marks for coke.

Great Britain.[1]—For the 39 full weeks worked during 1921 the total output of the United Kingdom averaged about 4,200,000 long tons per week, but rose considerably toward the close of the year, the week ended Dec. 17 having the record production of 5,030,000 tons. In the South Wales field that week was the largest for several years, with an output of over a million tons and an export from Bristol Channel ports of over half a million tons. The following table gives a comparison of output and consumption of coal in the United Kingdom in long tons:

Output and Consumption.	1913.	1920.	1921.
Output	287,500,000	229,500,000	163,000,000
Imports			3,400,000
Total supply	287,500,000	229,500,000	166,400,000
Exports:			
Coal	73,400,000	24,900,000	24,700,000
Coke and briquets	3,300,000	3,900,000	1,600,000
Bunkers	21,000,000	13,800,000	10,900,000
Total shipments	97,700,000	42,600,000	37,200,000
Available for home consumption	189,800,000	186,900,000	129,200,000

During the last 40 years there has been an almost unbroken decrease in the tons of coal mined per man per annum. Starting with the decade from 1882 to 1892, the output was an average of 297 tons, but it shrank rather steadily until, in 1920, it was only 184 tons per annum. In spite of this, however, the total output of the United Kingdom steadily rose, by employing more men in the coal mines, until in 1913 it reached its apex with a production of 287,500,000 tons. From this point the total output has also steadily declined, until in 1921 it was only 163,000,000

[1] *Suppl. to Comm. Rept.*, No. 1, 1922.

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tons. Added to these factors is the one that, although the total output of the United Kingdom was increasing, it was not holding its relative position as a producer of the world's coal, as the percentage of the world's coal furnished by the United Kingdom in 1899 was 30.4 per cent., but had gradually decreased to 21.7 per cent. in 1913.

Then came the war and its aftermath. The coal industry was taken out of the hands of private enterprise. Prices, consumption, export, all things were regulated. When the war was over, prices for coal rose still higher. The needs of Europe for British coal were imperative, and export prices reached such heights that the profits on export coal were used to keep down the price of domestic coal. The high prices attracted American export coal to Europe, a field that had previously been entered to a limited extent only. By the end of 1920, however, the edifice of high prices was already cracking at the foundation.

Shortly after 1921 opened, the first shock came when the French Coal Bureau set the maximum price of best Admiralty Welsh coal at 47s. 6d. The f. o. b. price at Cardiff was then between 74s. and 75s., thus practically eliminating the higher grades of Welsh coal. Reparation coal from Germany began to come more freely into the markets of France, Belgium, and Italy.

On Jan. 10 all restrictions on export coal and bunkers were removed and on Feb. 1 it was announced that from Mar. 1 Government control on the price of inland coal would be removed. Soon after it was decided to turn the mining industry back to private ownership entirely as of Mar. 31.

Then came the period of three months' stoppage, which terminated on July 4. The most important feature of the settlement was the fact that the question as to what wages were to be paid was to be settled on a different principle. Since 1875 wages had been paid on a sliding scale, which rose or fell with the selling price of coal. Now the sliding scale will rise or fall with the profits made by the industry. Inasmuch as profits are likely to vary among the different sections of the country, the United Kingdom has been divided into thirteen districts. The profits in the district taken as a whole are determined by a joint audit of the books in one month and the profits of that month determine the wages for the second month thereafter, *i.e.*, profits in January will determine wages in March, etc. Due to certain temporary provisions designed to lessen the shock of the inevitable fall in wages, the system did not come into full operation until October.

What of the future? Much will depend upon whether the curve of output per man will definitely and persistently reverse the downward tendency of the past 40 years. At the present time it is turning upward.

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Allowing for the fact that the miner underground is now working only seven hours instead of eight and not working a full week, the efficiency is about the same as in 1913. The factors which limit the demand for British coal in the world are German reparations coal, decreasing consumption due to trade stagnation, American competition, substitution of other sources of power, such as oil and water-power, schemes for economizing coal, such as low-carbonization, and the use of central heating instead of the domestic open grate. In general, it is probable that the demand for coal will gradually increase, but costs of production will continue higher than before the war.

Holland.—The total production of coal during 1921, 4,167,960 metric tons, was substantially the same as the year before, 4,115,629 tons, and compares with 3,540,064 tons in 1919, 3,399,000 tons in 1918, and much less in previous years. Production of lignite in 1921 was only 122,000 tons, compared with about 1,400,000 tons in 1920.

The coal supply for 1921 amounted to approximately 8,625,000 metric tons, as compared with 7,620,000 tons in 1920 and 7,554,000 tons in 1919.

Hungary.[1]—Production in Hungary before the war showed an average increase of 500,000 tons per annum, the total output being 10,000,000 tons in 1913. The total amount of coal in Hungary was estimated at that time at 1,717,000,000 tons. At present Hungary has 77 producing coal mines and the output is rapidly increasing. While the total output in 1920 amounted to 5,000,000 metric tons, production in 1921 is estimated at 6,000,000 tons.

There are at present several projects under consideration for the use of lignite. Hungarian lignite can not well be used in boilers, as it contains much sulphur. On the other hand, Hungarian lignite also contains a considerable amount of tar, which has an enormous importance in the chemical industry. It is intended now to erect large electric generating plants, using lignite for that purpose, as well as plants for the purpose of producing tar. Such plants are to be erected at Rozsaszentmarton (near Gyongyos) and one at Ajka, where the lignite would be used for the generation of electricity for driving the railway around Lake Balaton. The lignite mine of Varpalota is to be used for a similar purpose.

India.[2]—The report of the Chief Inspector of Mines for 1921 shows that the total output of coal in British India amounted to 18,358,934 long tons, to which Bihar and Orissa contributed 12,964,659 tons, and Bengal 4,259,642 tons. In the last three fiscal years the total importation of coal and coke has advanced from 39,000 tons and 87,000 tons to 1,501,000 tons. To the latter total, in 1921–22 the United Kingdom

[1] *Comm. Rept.*, Apr. 10, 1922.
[2] *Coll. Guard.*

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contributed 705,000 tons, Natal 340,000 tons, Portuguese East Africa 268,000 tons, and Australia 88,000 tons.

Italy.—Lignite output was 1,019,700 metric tons during 1921, as compared with 1,571,735 tons in 1920 and 1,129,197 tons in 1919. Coal production is insignificant, only 111,400 tons being mined last year. The lack of coal in Italy gives importance to the country's lignite reserves and Italian engineers are actively considering the possibility of utilizing this fuel instead of coal wherever possible.

Japan.—The coal market remains inactive and there is little or no hope of a revival in the near future. The total quantity of coal brought over from 1920 was 1,478,000 tons, and in April an agreement was reached among mine owners of Kiushu, Hokkaido, and the Joban district to restrict the output. The average monthly output in the country in 1920 was 2,568,000 metric tons, while the total for 1921 was 24,500,000 tons. The total output during 1920 was 30,819,898 tons. In 1919, when the market experienced a boom unprecedented in history, the output amounted to 32,703,338, tons this being a record for 30 years.

New South Wales.—The output of coal in the State of New South Wales, Australia, for 1921 amounted to 10,793,387 long tons. These figures constitute a record for Australia, being 77,388 tons in excess of the output for 1920. Prior to 1920 the record stood at 10,414,165 for 1913, but there was a considerable falling-off in the production for the years 1915 to 1919, inclusive. This output is especially remarkable in view of the constantly recurring stoppages of work at the various collieries. Coke made during 1921 amounted to 592,097 tons, valued at £1,029,694, being an increase of 24,528 tons and £185,503 in value as compared with the previous year. This quantity has only been once exceeded, in 1918, when 608,492 tons was produced; the value of the production is the highest recorded in any year.

Industrial trouble at the mines so reduced the coal output that it was not equal to domestic demand. As a protective policy an embargo was placed against the exporting of coal during part of the year.

Coal to the amount of 4,558,838 long tons was shipped from Newcastle, New South Wales, in 1921. While the bulk of this went to other Australian States (1,486,116 tons to Victoria and 789,393 tons to South Australia) and to New Zealand, appreciable exports overseas were made. New South Wales is the only Australian State exporting coal, though four of the six states have black coal deposits and all have coal of some kind.

The principal deposits of New South Wales, with an average annual production of 9,000,000 tons, have an area of about 16,000 sq. mi., of which Newcastle is the coastal center. This coal is in six main seams, the top one of which reaches its greatest worked depth under Sydney

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Harbor, whence coal has been mined at 2884 ft. The aggregate thickness of the six seams is estimated at 13,000 ft. and the workable content at 1,000,000,000 tons.[1]

Poland.—Coal production in Poland, not counting Polish Upper Silesia, continues to increase. The total production for 1921 (about 7,570,000 metric tons) represents an increase of one-sixth over that of 1920 and was equal to more than five-sixths (84.4 per cent.) of that of 1913. In fact, the production of 1921 exceeded that of any pre-war year except 1913. The output of lignite also shows an increase, from 248,477 tons in 1920 to 270,415 tons in 1921, the latter figure being two-fifths greater than the 1913 production.

Queensland.[2]—The total quantity of coal raised in Queensland last year was 954,763 long tons, of the value of £831,483, this being, as compared with the 1920 yield, a decrease of 155,150 tons in quantity and £10,068 in value. Probably the greater part of this decline may be attributed to the general falling-off in mining operations that has been an unfortunate feature of the year's record.

The average cost per ton of the coal output at the pit's mouth for the whole State for 1921 (18s. 4.3d.) was 3s. 2.4d. more than in the preceding year. The principal decrease in yield was in the Ipswich district, and there were also lessened returns from the Darling Downs, Clermont, Bowen, and in the North, the decrease in the last-named district being the result of the explosion at the Mount Mulligan colliery. Of the total yield, Ipswich turned out 666,236 tons—about 97,350 tons less than for the year 1920.

Russia.[3]—The chief source of coal always has been the Donetz Basin, which lies just north of the northeastern projection of the Azov Sea. It is situated in the immediate vicinity of the rich iron-ore mines of Krivoi-Rog, and also happens to be the only source of production in all Russia of metallurgical coke. Next in importance are the mines of the Ural, which likewise produce a small quantity of anthracite, and the Moscow Basin which, although centrally located, produces only lignite. Mining of the extensive and easily accessible deposits of black coal of the Kuznetsky Basin and Tsheremkovo, in western Siberia, was only begun, more or less intensively, after the outbreak of the war. Of minor importance are the Turkestan fields and those of Borovichi, in the Novgorod Province, where low-grade soft coal is produced.

From 86 per cent. of Russia's total output in 1914, the Donetz output dropped to 75 per cent. in 1918, 64 per cent. in 1919, and 55 per cent. in 1920. In the first nine months of 1921 its output averaged 60 per cent.

[1] *Comm. Rept.*, May 15, 1922.
[2] *Queens. Govt. Min. Jour.*, Apr. 15, 1922.
[3] *Comm. Rept.*

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of the total. The variations of the Donetz output are traced in the appended chart. The figures in the chart represent gross production, from which the consumption of the mines themselves must be deducted. Production figures are shown in millions of poods (62 poods = 1 gross ton).

In July, 1921, a marked change in methods was resorted to by the Soviet Government. Although but few mines were restored to private

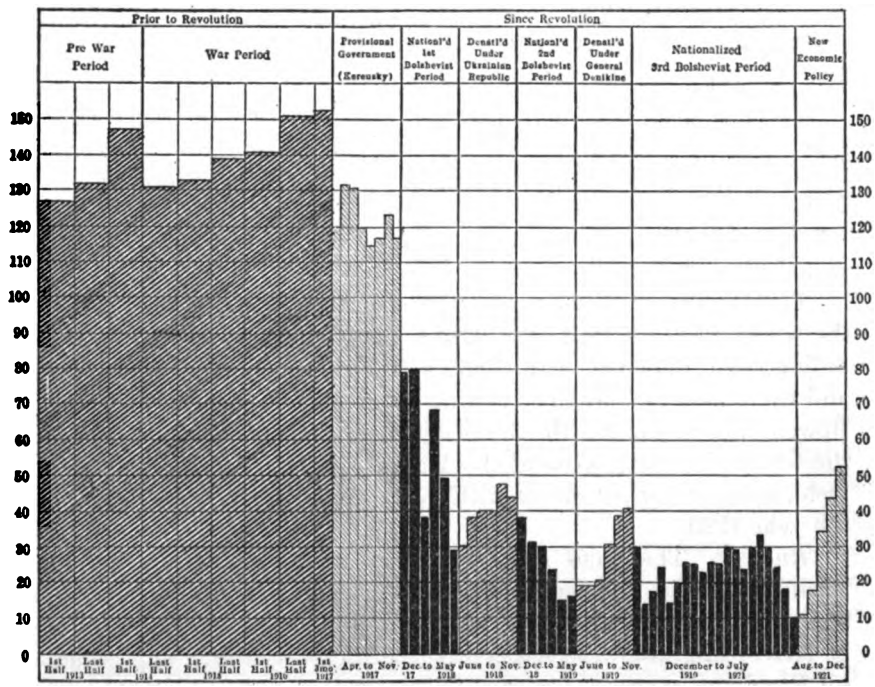

FIG. 7.—Coal production in the Donets Basin, Russia.

exploitation, a system of centralized and unified administration was restored in the nationalized mines, with unlimited authority placed in the hands of the chief administrator. The managerial staff and the experts were afforded a liberal remuneration for their services and a proportionate bonus on the tonnage output. Above all, the system of equalized wage payment, in the form chiefly of uniform rations, was discarded and a graduated system of direct output pay, on a sliding scale, introduced in its stead for all hands. The effect of the new economic system was important and is worthy of some detail, as shown in the following table:

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PRODUCTION OF COAL IN DONETZ BASIN AND NUMBER OF LABORERS EMPLOYED IN MINES, JULY–DECEMBER, 1921

Months.	Production in Thousands of Poods (a) Black Coal.	Anthracite.	Total.	Net.	Men Employed.
July	9,600	(a)	9,600	500	107,500
August	9,300	2,000	11,300	3,290	107,140
September	15,280	3,100	18,380	9,910	93,640
October	25,600	9,400	35,000	24,700	97,200
November	29,500	13,500	43,000	24,600	106,000
December	35,920	17,130	53,050	34,050	116,300

(a) Sixty-two poods = 1 gross ton. (b) Not reported.

The increase in the production of anthracite during the latter part of 1921 is noteworthy. It formed about 32 per cent. of the December production.

Additional light is thrown on the above figures of the net output by the fact that 700 coal pits were worked in July, while in November the production was concentrated in 281 pits, with 49 more pits slated for shut-down as soon as available supplies were exhausted. This concentration of work in the best-equipped pits was dictated not alone by the scarcity of skilled labor but by the acute shortage of mine props and beams, coal-cutting machines, electric armatures and steel.

An important factor in the coal situation at present is the shortage of shipping facilities. Coal is piling up in the Donetz Basin—only 13,700,000 poods was shipped out in October, the November shipments were 16,000,000 poods, and the December shipments about the same. The stocks on hand on Dec. 1, 1921, amounted to 78,600,000 poods—23,400,000 poods of bituminous coal and 55,200,000 poods of anthracite. On Jan. 1, 1922, stocks on hand were 98,200,000 poods—33,100,000 poods of soft coal and 65,100,000 poods of anthracite.

TOTAL PRODUCTION OF RUSSIAN COAL FIELDS
(Millions of Poods)

Districts.	1914.	1916.	1917.	1918.	1919.	1920.	First Nine Months of 1921.
Donetz Basin	1,684	1,752	1,516	527	325	278	196.8
Ural district	84	92	98	37	44	57	45.12
Moscow district	18	42	45	23	22	37	31.18
Turkestan and Caucasus	13	15	13	6	11	10	(a)4.67
Borovichi	.....	.....	.....	.....	.....	2	0.67
Eastern Siberia	88	118	113	53	33	30	.....
Western Siberia	60	82	94	56	51	52	49.8
Totals	(b)1,947	2,101	1,879	712	486	(c)466	328.24

(a) January to October, inclusive.
(b) Exclusive of Dombrova (Poland) mines, lost by Russia in 1914.
(c) The total for 1920 was reported to mining conference at under 431,700,000 poods (*Economic Life*, No. 287, 1920).

Total production during the first quarter of 1921 was 114,900,000 poods and rose to 141,300,000 poods during the second quarter; in the third quarter, however, the production fell to 72,000,000 poods. The output of the Donetz Basin was principally responsible for this heavy

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fluctuation, rising from 72,000,000 poods in the first quarter to 85,000,000 poods in the second quarter and declining to 39,000,000 poods in the third quarter.

Spain.—About 7,250,000 tons of coal is consumed annually in Spain, which is somewhat in excess of domestic production. The Government is endeavoring to stimulate home production by a protective tariff, but it is not probable that a high import duty will be permanently maintained, as it has been the policy of the Government during late years to encourage the development of industries in Spain, for which cheap coal is necessary.

The lessened activities in coal mining have been due to foreign competition. The present high cost of operating coal mines in Spain is unprecedented. Coal mining has also suffered as a result of the decrease in coal orders consequent upon the local industrial depression, the failure of employers and employees to arrive at a working agreement, and unsolved transportation problems.

Practically all of the coal imported into Spain comes from Great Britain.

PRODUCTION OF COAL IN SPAIN

Year.	Production, Metric Tons.				Imports, Metric Tons.
	Anthracite.	Bituminous.	Lignite.	Total.	
1913	232,500	3,783,200	276,700	4,292,400	3,098,300
1914	228,300	3,905,100	291,100	4,244,500	2,875,800
1915	222,600	4,135,900	328,200	4,686,700	1,905,000
1916	268,100	4,847,500	473,100	5,588,700	2,151,200
1917	310,900	5,024,800	636,800	5,972,500	1,167,300
1918	617,200	5,761,000	785,600	7,164,400	528,100
1919	398,771	5,304,866	539,872	6,243,509	804,944
1920	263,338	5,104,287	552,866	5,920,491	332,362
1921	292,591	4,718,838	408,684	5,420,113	969,393

Spitzbergen.[1]—The chief interest in the group of islands comprising Spitzbergen is based on their great coal deposits, according to a report by Consul Benjamin F. Chase, at Trondhjem, Norway. With incomplete explorations, it is estimated that there are at least 10,000,000,000 tons of coal of various grades in Spitzbergen, some of it below sea-level. The coal lies in veins ranging in thickness from 2½ to 10 ft., with an average of 4 ft. and easily worked.

The output for export, bunker, and other purposes is given as follows:

	Long Tons.		Long Tons.
1909	15,000	1915	28,000
1910	20,000	1916	20,000
1911	25,000	1917	40,000
1912	40,000	1918	60,000
1913	35,000	1919	80,000
1914	40,000	1920	95,700

Estimate for 1921, 220,000 tons.

[1] *Comm. Rept.*, Jan. 9, 1922.

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Switzerland.[1]—The output of coal declined greatly in 1921, amounting to only 10,714 metric tons, against 74,590 tons in 1920 and 64,902 tons in 1919. This may be attributed to the failing of the local market occasioned by the receipt of cheaper and better coal from abroad.

Union of South Africa.—It has been ascertained that the total coal production of the Union of South Africa for the year 1921 was 10,331,886 metric tons as against 10,408,497 tons in 1920. This indicates a decrease in output, and is accounted for by the recent labor troubles on the coal-fields. During the year the amount of coal shipped as cargo was 1,795,-093 tons, which constitutes a record exceeding the previous year (1920) by 493,821 tons.

MARKETED COAL PRODUCTION IN THE UNION OF SOUTH AFRICA
(In long tons)

Year.	Transvaal, Tons Sold.	Natal, Tons Sold.	Union of South Africa.	
			Tons Sold.	Value.
1917	6,641,229	2,890,296	10,382,920	£3,275,608
1918	6,438,961	2,607,133	9,877,325	3,244,596
1919	6,622,313	2,801,004	10,266,135	3,416,244
1920	7,180,124	3,321,594	11,473,452	4,506,572

This compares with a production of 8,117,078 tons valued at £1,999,-378 for the Union in 1913.

There were 76 producing collieries in the Union of South Africa in 1921, of which 41 were in the Transvaal, 27 in Natal, 3 in the Orange Free State, and 5 in the Cape. The Middelburg area produces most of the coal mined in the Transvaal and, in fact, more than the whole of Natal. In the Transvaal coal mining has also been carried on in the Springs-Brakpan area of the East Rand and Vereeniging, on the Vaal River, and recently mines have been opened up at Grootvlei, southeast of Heidelberg, and at Breyten, in the Ermelo-Carolina district. A marked feature of the coal measures of the Transvaal, particularly those of Middelburg section, is the rapid variation in thickness and character of all the constituent beds, particularly the lower ones.[2]

The coal-mining industry in Natal has been centered in the Newcastle and Dundee districts, in the northwestern part of the Province, but of late operations have been extended eastward. The Natal coal deposits, which are frequently of an anthracite nature, produce the best coal mined in the Union. It is an excellent steam coal, although often high in sulphur.

[1] *Comm. Rept.*, June 5, 1922.
[2] *Comm. Rept.*, July 10, 1922.

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COBALT

By C. W. Drury

Contrary to the several reports that have appeared in the technical press of the discovery of large quantities of cobalt, no deposits of importance were developed during the year 1921.

An account[1] of a deposit of cobalt in Jackson County, Oregon, states that a quantity of 4½-per cent. ore has been blocked out. Further work on this deposit may be undertaken during 1922.

From the mines of Idaho there were produced in 1918, from 3571 tons of ore, 49 tons of concentrates, analyzing 17.74 per cent. cobalt.[2]

Cobalt is found[3] in two South American countries, but production is spasmodic and of no great importance. In the Chilean Province of Atacama veins of cobalt oxide, arsenate, and sulpho-arsenide, in which the ore averages 4 per cent. cobalt, have been worked, the chief mines being about 30 miles from the Port of Huasco. Rich veins of cobalt ore are found in the silver mines of this province as well as in Coquimbo and Santiago. In Argentina cobalt ores have been reported from La Rioja and Catamarca.

A report[4] from Melbourne stated that a shipment of 77 tons of 25-per cent. cobalt ore was sent from Mount Cobalt, Northern Queensland, to Swansea. The report also states that the company expects to erect a concentrating plant at a cost of $200,000 to treat the low-grade ores at the mine.

The total exports of cobalt ore from Australia in 1921 were 431 long tons.

Cobalt minerals, chiefly smaltite and erythrite, and veins containing gold, lead, silver, and antimony have been found at The Pas mineral belt,[5] Manitoba, Canada.

Nickel and cobalt[6] ores are reported in the Tamazula district, Durango, Mexico, but their occurrence has not been verified.

Several lots of cobalt ore averaging from 6 to 28 per cent. cobalt were recently shipped to the Shepherd Chemical Co. at Cincinnati, Ohio, from the Goodsprings district, Nevada, the ore coming from the Copper

[1] *Eng. Min. Jour.*, **112**, 173 (1921).
[2] *Chem. Met. Eng.*, **26**, 700 (1922).
[3] Imperial Mineral Resources Bureau.
[4] *Min. Jour.*, Oct. 15, 1921.
[5] R. C. Wallace, *Min. Eng. Rec.*, **25**, 109–113 (1920).
[6] *Eng. Min. Jour.*, July 30, 1921, p. 173.

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Chief, High Line, and Columbia mines.[1] A considerable tonnage of cobalt ore assaying 10 per cent. is available in this district. The mineral occurs in the form of oxides and is known as heterogenite.

Production.—The following figures show the Canadian production in 1918, 1919, 1920, and 1921.[2]

PRODUCTION OF COBALT IN CANADA, IN POUNDS

	1918.	1919.	1920.	1921.
Cobalt oxide	1,176,166	784,730	752,434	216,871
Cobalt metal	473,463	151,446	227,626	22,216
Cobalt sulphate	43,097	57,103	1,717	.....

In addition to the above figures 294,497 lb. of residues having a market value of $49,724 were shipped.

The works of the Missouri Cobalt Co., Fredericktown, Mo., were closed throughout the year 1921.

Trade.—The year 1921 showed a marked decline in the price of cobalt metal and oxide. The price of cobalt metal dropped from $6.00 in January to $3.00 in December, and during the same period the price of oxide declined from $4.00 to $2.00 per pound.

IMPORTS INTO THE UNITED STATES OF COBALT PRODUCTS, COBALT, COBALT ORE AND ZAFFER, IN POUNDS
(Fiscal years ending June 30)

From	1915.	1916.	1917.	1918. (a)	1919. (a)	1920. (a)	1921. (a)
Germany	1,761	.....	.....	.....	.....	220	3
England	.....	.....	.....	.....	2,586	50	6,720
Canada	22,334	144,270	138,260	504,401	74,970	157,142	39,376
Total	24,095	144,270	138,260	504,401	77,556	157,412	46,089
Imports of cobalt oxide	190,145	238,934	236,822	208,596	131,424	202,704	164,003

(a) Calendar years.

Metallurgy.—A number of patents have been granted during the year dealing with the metallurgy of cobalt. In practically all cases chlorine gas is used extensively. One patent has been assigned to the Hooker Electrochemical Co., Niagara Falls, N. Y. The Electro Bleaching Gas Co., Niagara Falls, is reported to have come to a satisfactory working agreement with the Coniagas Reduction Co. to recover cobalt from residues and ores from the Coniagas mine. In addition to producing cobalt metal and oxides, the Electro Bleaching Gas Co. plans to manufacture caustic soda, chlorine gas, and liquid chlorine at the Thorold plant.

The Ontario Smelters and Refiners, Ltd., Welland, Ont., which recently purchased the Metals Chemical Co., Welland, have according to a newspaper report authorized an assignment for the benefit of its creditors.

[1] *Eng. Min. Jour.-Press*, 113, 838 (1922).
[2] Private communication, Ontario Bureau of Mines.

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Uses.—Cobalt compounds, especially the acetate, resinate, and oleate are being used extensively as "dryers" in the paint and varnish industries.

A patent[1] was granted to the Chile Exploration Co. as assigners of Colin G. Fink. The patent covers the use of a cobalt-silicon alloy as an anode for copper deposition. A lengthy discussion of the application of such an alloy is given in the patent. Another patent[2] was granted to Colin G. Fink for a similar alloy for the same purpose, this alloy being composed of cobalt with 7 to 20 per cent. of silicon, manganese, and chromium.

During the year 1921, further investigation work on the use of cobalt as one of the main constituents in steels for permanent magnets has been conducted. Two articles[3] on this subject summarize the work undertaken. The authors claim for K. S. magnet steel and "Permanite," as the cobalt steels are designated, an extremely large coercive force combined with higher residual magnetism than is found in the ordinary tungsten steels. Cobalt magnet steel is the product of the Cobalt Magnet Steel Co., Ltd., Sheffield, England, according to a report in *The Iron Age*, Mar. 16, 1922.

Bibliography and Patents

Anon.—Cobalt Magnet Steel. *Iron Age*, Feb. 2, Mar. 16, 1922.

Bauer and Piwowarsky.—Nickel and Cobalt in Iron. *Stahl u. Eisen*, Sept. 30, 1920.

Becker, E.—Steel Alloy of Great Toughness and Resistance to Wear and of Low Magnetisability. Brit. Pat. No. 338664, May 12, 1919. The steel contains 2.5–15 per cent. manganese, at least 4 per cent. nickel or cobalt or both, and 0.2–11.0 per cent. tungsten, and may be improved by the addition of up to 2 per cent. vanadium. The alloy has the advantage over plain manganese steel that it is non-rusting.

Fahrenwald, F. A.—Iron-cobalt-chromium Alloy. U. S. Pat. No. 1357549, Nov. 2, 1921. An alloy resistant to high temperature and suitable for furnace parts is formed of Fe 70 per cent., Co 13.5, Cr 15, C 0.5, Si 0.5, and Mn 0.5 per cent.

Guillet, Leon.—Cobalt Brasses. *Chem. Met. Eng.*, **24**, 439–43 (1921).

Hadfield, R. A.—Alloys. Brit. Pat. No. 164039, Nov. 28, 1919. Steel alloys suitable for permanent magnets and other purposes are made by alloying with carbon steel containing about 0.25–1.5 per cent. carbon, about 5–19 per cent. of cobalt and tungsten (or vanadium or molybdenum); chromium, nickel, and tungsten (or vanadium or molybdenum) may also be added, and also up to about 1 per cent. manganese. The tungsten may vary up to about 10 per cent. and the nickel and chromium up to about 5 per cent. each. Cast ingots of the alloys may be heated to about 1000° C., forged, hardened at about 850 or 900°, and magnetized.

Lundell and Hoffman.—Determination of cobalt and nickel in cobalt steels. *Jour. Ind. Eng. Chem.*, **13**, 540–3 (1921).

Souder and Hidnert.—Thermal Expansion of Nickel, Monel Metal, Stellite, Stainless Steel, and Aluminum. Scientific Paper No. 426, U. S. Bur. of Standards.

[1] Brit. Pat. No. 157871 (1920).
[2] Can. Pat. No. 218245 (1922).
[3] Honda and Saite, "K. S. Magnet Steel," *Electrician*, **85**, 705 (1920). "Steels for Permanent Magnets," *Electrician*, **86**, 327 (1921).

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UDY and RALSTON.—Separating cobalt and nickel. U. S. Pat. No. 1365358 (Jan. 11, 1921).

WANDERSEE, J. F., PERETTO, R., and ALBRECHT, T. A. L.—Cobalt Alloy. U.S. Pat. No. 1376056 (Apr. 26, 1921). (Assignors to Ford Motor Co.) An alloy adapted for the manufacture of cutting-tools is formed of Co 35–65 per cent., C 2–5, Cr 15–40, and W about 11 per cent. Also U. S. Pat. No. 1376062 (Apr. 26, 1921). An alloy adapted for cutting-tools is formed of Cr 20–35 per cent., W 5–20, Fe 1–15, Co 40–60, and C 2–5 per cent.

WESTCOTT, E. W.—Treatment of Arsenic Ores. U. S. Pat. Nos. 1406595, 1406596, and 1406507. (Assignor to Kalmus, Comstock and Westcott.)

WHITBY and BEARDWOOD.—Separation of Nickel from Cobalt. *Jour. Chem. Met. Min. Soc. So. Afr.*, **21**, 199–200 (1921); *Eng. Min. Jour.*, **112**, 375 (1921).

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COPPER

By Walter Harvey Weed

The year 1921 was the worst that the copper industry has ever had or probably ever will have. At no other time since copper mining became an important business have the mines been shut down for a full year, the employees dismissed, and the warehouses full of unsold metal. The culmination of a period of unprecedented depression that began in 1920 occurred in 1921, despite the fact that producers tried hard to avoid the crisis by reducing the price of the metal below its actual cost of production. The huge unsold surplus stock, currently estimated at 1,100,000,000 lb. at the beginning of the year, was the direct cause of this depression, but was itself a result of the impaired buying power of Europe, and of a domestic consumption that was but half that of former years.

The world's production for 1921 is estimated at 587,867 short tons, compared with 1,041,806 in 1920. As even the 1920 figures are not yet obtainable for some countries, this figure is partly based on proportionate productions in former years, so that the figure is not accurate.[1] The United States continued to produce the bulk of the world's copper despite the curtailment of its production during the first three months and the complete shut-down of all its larger mines and smelters for the remainder of the year. Smelter production from domestic ores was 505,586,098 lb. in 1921 compared with 1,209,061,040 in 1920 and a mine production of 1,224,550,151 lb. in 1920.

Official figures show that surplus stocks of new refined copper were not as great as generally supposed, being 459,000,000 lb. of refined copper on Jan. 1, 1922, compared with 641,470,486 lb. a year before, and 702,121,233 lb. Jan. 1, 1920. Adding unrefined or blister copper in transit brings the total surplus stock on hand at the beginning of 1922 to 742,000,000 lb. compared with 1,124,000,000 at the beginning of 1921 and 904,000,000 Jan. 1, 1920.

The great South American mines did not suspend operations in 1921, although their production was somewhat less than in 1920. The African output was about normal and Australia below normal, while production

[1] If the United States production was 60 per cent. of the world's total, the world's production was about 1,050,000,000 lb.

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of Japan did not meet that country's local demands. The Russian mines were practically idle, supplying less than 1 per cent. of their normal amount.

The cost of production was high in 1921, for most of the companies operated only a quarter of the year, and even the few mines that were operated continuously had costs a trifle above 1920 figures./

The future of the industry has been interestingly discussed by Mr. C. F. Kelly, the president of the Anaconda Copper Co., in a paper of which the optimism and sound reasoning has attracted much attention. In this article Mr. Kelly says:

To appraise intelligently the situation today, it is only necessary to scan the industry for a period of 20 years. This period, brief in time, has been epochal in accomplishment, for during it the production of ore, beneficiation of its contents, and consumption of the product outstripped all previous periods and established a record that rivals the achievement in any other line of industrial effort.

The war, with the accompanying necessity for metal for munition purposes, completely dislocated the industry, and while apparently giving it a temporary prosperity, resulted in seriously impairing its status.

The world's production of copper in 1900 was approximately one billion pounds. Of this total output, the production of the United States was approximately 55 per cent.

The succeeding decade was marked by an extraordinary increase in production, due generally to bringing into operating activity the low-grade copper deposits, known as the porphyries, capable of making a large output upon a relatively small capital investment and at a comparatively low cost.

In 1912, the world's production had increased to 2,240,246,177 lb., and that of the United States to 1,243,268,720 lb., an increase above the output of 1900, in both foreign and domestic, of about 100 per cent. The percentage of domestic production remained about 55 per cent. The peak of the world's production was reached in 1917, with an output of 3,137,659,472 lb., of which 1,886,120,721 lb., or 60 per cent., was domestic. The peak of the United States production occurred in 1916, when an output was reached of 1,927,850,548 lb., or 62.7 per cent., of a total of 3,070,930,639 lb. for that year.

It is interesting to note that while the world's production has increased, from 1900, a maximum of about 187 per cent., and that of the United States a maximum of 218 per cent., the proportion maintained between domestic and foreign production has been fairly constant, on a percentage basis, to wit: 55.6 per cent. in 1900, a maximum proportion of 62.7 per cent. in 1916, and 62.3 per cent. in 1920.

Any survey of the copper industry must look at this large increase of production squarely, and no forecast that attempts either to disregard or minimize its importance can find acceptance by those who give the matter intelligent consideration. Conversely, production data in themselves mean little, for to draw a conclusion from the increase above cited, without further study, would be to measure its consequence from a standpoint that disregarded the changes that have occurred in consumptive demand, actual or potential, during the period under discussion.

As indicative of the ultimate uses of copper, estimates of consumptive demand in the United States for the years 1919 and 1920 are submitted.

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ESTIMATED CONSUMPTION OF COPPER IN THE UNITED STATES BY INDUSTRIES

	1919.		1920.	
	Pounds.	Per Cent.	Pounds.	Per Cent.
Electrical manufactures	284,000,000	23.48	340,000,000	26.12
Telephones and telegraph	65,679,218	5.43	100,000,000	7.68
Wire (not included elsewhere)	160,000,000	13.23	190,000,000	14.59
Automobiles	92,965,000	7.68	99,320,400	7.63
Locomotives	8,998,000	0.74	9,457,250	0.73
Railway cars—freight	15,676,400	1.30	7,543,500	0.58
Railway cars—passenger	156,400	0.01	576,000	0.04
Steam railways—electrified	250,000	0.02	2,200,000	0.17
Shipbuilding	101,884,625	8.42	61,906,325	4.76
Buildings	76,778,800	6.35	53,443,200	4.10
Ammunition	23,000,000	1.90	23,400,000	1.80
Fire extinguishers	2,000,000	0.16	2,100,000	0.16
Pins	2,000,000	0.16	2,000,000	0.15
Valves	10,000,000	0.83	10,000,000	0.77
Coins	2,075,321	0.17	3,148,863	0.24
Bearing metal—steam railways	45,000,000	3.72	45,000,000	3.46
Cash registers	1,300,000	0.11	1,340,000	0.10
Condensers	10,000,000	0.83	6,000,000	0.46
Miscellaneous	150,000,000	12.40	180,000,000	13.83
Total	1,051,763,764	86.94	1,137,435,538	87.37
Exported in manufactures	157,965,641	13.06	164,420,412	12.63
Total in manufactures	1,209,729,405	100.00	1,301,855,950	100.00

On Jan. 1, 1919, the stock of copper, according to the best available statistics, assumed the unprecedented total of 2,278,812,300 lb., made up as follows:

	Copper, Pounds.
Producers:	
Crude	340,314,000
Process	319,196,000
Refined	180,000,000
Total	839,510,000
Governments:	
United States	128,714,200
Great Britain	179,200,000
France	168,000,000
Italy	67,200,000
Germany	67,200,000
Japan	20,160,000
Total	630,474,200
Scrap, in Brass, etc.:	
United States	92,028,100
Great Britain	369,600,000
France	224,000,000
Italy	44,800,000
Germany	67,200,000
Japan	11,200,000
Total	808,828,100

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To this amount, in order to bring the situation to the beginning of 1921, there should be added the production of 1919 and 1920, respectively, as follows:

	1919.	1920.
United States	1,310,972,580	1,343,945,000
Others	809,909,940	813,893,230
Total	2,120,882,520	2,157,838,230

This gives a total for the two years of 4,278,720,750 lb., which, added to the stock of Jan. 1, 1919, gives a total of 6,557,533,050 lb. to account for.

The stocks on hand Jan. 1, 1921, have been estimated at 1,764,632,540 lb. made up as follows:

	Copper, Pounds.
Producers:	
Crude	300,550,000
Process	229,002,000
Refined	641,474,000
Total	1,171,026,000
Government:	
United States	14,158,520
Great Britain	26,087,040
France	12,658,240
Italy	58,240,000
Japan	73,136,000
Total	184,279,800
Scrap, in Brass, etc.:	
United States	10,606,740
Great Britain	302,400,000
France	67,200,000
Italy	29,120,000
Total	409,326,740

The difference between the above 6,557,533,050 lb. and 1,764,632,540 lb. equals 4,792,900,510 lb., an indicated average consumption for the years 1919 and 1920, respectively, of 2,396,450,255 lb. This is an amount greater than the entire copper industry ever produced prior to the year 1915, and if during the years 1919 and 1920, the world, with the far from normal export demand that existed, actually furnished a market for more than 2,300,000,000 lb. of copper annually, instead of there being any cause for pessimism, the facts should be regarded as a conclusive demonstration of the basic soundness of the industry, for there can be no doubt that during the years 1916, 1917 and 1918, production was forced beyond a normal economic maximum, and upon a resumption of normal business, the difference between the demand of 1919 and 1920 and that which should ensue will furnish a market for the normal maximum economic output that the industry can furnish.

During the two years above analyzed, it is estimated that the producers furnished, from current production, 3,947,204,750 lb., and that from Government stocks and scrap, brass, etc., a total of 446,194,400 and 399,501,360 lb., respectively, was obtained.

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This brings us to a consideration of the present status of the industry. Actual statistics are not yet available, but it is well known that the great part of Government stocks and scrap metals have been liquidated. Stocks in hands of producers have decreased with satisfying rapidity, until the close of the year finds the metal in a fair statistical position, most reliable estimates placing the total of all copper at smelters and refineries, in blister, process or refined form, at about 850,000,000 lb. The greater part, approximately 550,000,000 lb., is refined. This is somewhat more than should be carried under normal conditions and tends to obscure the actual situation. Probably more than one-third of this amount has already been sold for future delivery, without considering the sale to the Copper Export Association for shipment abroad. The remainder, supplemented by current production from the few properties now operating, can meet even the present demand for only a few months—and what then?

Consumption in 1919 and 1920 averaged practically 200,000,000 lb. per month. The sales for the last quarter will average about 140,000,000 lb. per month. The decrease in stock, after taking in current production, would be more than 70,000,000 lb. per month. It takes, under favorable conditions, three months, on an average, for copper in the mine to be put in marketable form as refined electrolytic copper. This means that when the industry is under way and running smoothly, assuming a market demand of 150,000,000 lb. per month, 450,000,000 lb. of copper will have to be mined to fill up the reservoir from mine to mill to smelter to refinery, including working stocks on hand, before any copper from the mines now down is available for the fabricator. As a matter of fact, how long it will take to reach a reasonable output, no one can say.

Conditions at the beginning of the year 1921 were decidedly bad. A heavy surplus of unsold metal and a stagnant market even at the lowest price recorded for 20 years, with no improvement in sight, made further operations hopeless. The only favorable feature of the situation was the very material assistance given the industry by the Pittman Act, which fixed the price to be paid for silver at $1 an ounce, and this metal is almost universally present in the copper ores of the United States. There was a general cessation of mining and smelting in April, but maintenance expenses continuing throughout the year entailed a heavy loss.

When the leaders of the industry recognized that a suspension of work was imperative, there was such a general acquiescence to their judgment that concerted action was taken and a general shut-down occurred. Its result was beneficial, but the cost was enormous, the six most prominent copper-producing companies reporting an aggregate deficit of $57,277,864 for the year. This sum, which includes depletion, depreciation of plant, etc., is equivalent to a loss of 5.72 cts. per pound on 1,000,000,000 lb. of copper.[1]

By the end of 1921 it was apparent that the worst was over. The overstocked market was largely the result of underconsumption. The surplus of primary copper was being cleaned up, and the large amount of secondary metal salvaged from war material had been largely absorbed by consumers.

[1] *Boston News Bureau*, May 26, 1922.

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The stoppage of mining operations in April, 1921, was practically general throughout the United States, Canada, and Mexico, and at many properties the entire mine organization was dismissed, though a skeleton staff and a few miners were retained by most companies to keep the mines in good condition and to do a small amount of development work. One beneficial result of the shut-down has been an adjustment of the employment situation and the elimination of the radical element from the ranks of mine laborers. This and the need of employment, will, it is believed, remedy the inefficiency which, with the inflated wage-scale, has so greatly increased the cost of production during the past six years.

Production

The smelter output of copper for 1921 was 505,586,098 lb., a decline of over 50 per cent. below the 1920 figure of 1,209,061,040 lb. The refinery output, as reported by the U. S. Geological Survey, was 1,020,027,096 lb., a decrease of 614,881,548 lb. below the 1920 figures. This amount includes 410,612,840 lb. of copper of foreign origin, largely from South America, from mines which were operated continuously throughout the year.

Six of the 22 larger producers of America operated continuously, so that the figure given for the year's production does not merely represent 3 months' production of all the mines, but is swollen by the full year's production of the few companies that continued in operation, namely, Kennecott Copper, Miami Copper, Davis Daly, Quincy, Copper Range, Mohawk, Wolverine, New Cornelia, Tennessee Copper, Ducktown Sulphur, Copper & Iron Co., and a few smaller properties.

The following table shows the amount of copper produced in each state, based on smelter returns:

SMELTERS' PRODUCTION OF COPPER IN THE UNITED STATES[1]
(In pounds)

State.	1916.	1917.	1918.	1919.	1920.[2]	1921.[2]
Alaska	115,933,315	92,094,023	64,326,616	53,560,128	66,093,924	76,808,114
Arizona	662,630,286	704,156,391	787,338,533	531,777,990	552,988,731	155,165,656
California	51,358,334	46,824,320	43,623,933	21,691,192	11,822,928	15,906,883
Colorado	9,802,183	11,894,900	5,930,200	13,334,000	4,282,616	6,592,598
Idaho	6,741,001	6,401,938	5,051,531	2,737,800	1,922,116	1,971,623
Michigan	270,058,601	274,936,234	236,243,679	163,003,513	153,483,952	100,918,001
Montana	351,995,058	277,362,836	323,377,564	153,903,261	177,743,747	49,471,206
Nevada	100,143,481	115,436,671	115,842,177	63,179,794	85,580,322	15,129,116
New Mexico	83,013,805	110,020,997	92,813,432	54,827,501	82,159,751	18,076,909
Utah	225,396,806	244,443,071	235,978,152	123,124,850	110,357,748	45,831,959
Washington	(a)	2,152,560	2,290,600	2,667,038	2,125,586	598,658
Wyoming	(a)	(a)	(a)	(a)	24,256	9,830
East and South	20,018,261	18,704,304	17,704,875	20,072,119	17,349,827	15,084,884
Other States	15,685,226	18,127,558	7,791,545	5,736,027	3,126,436	4,020,661
Total	1,942,776,309	1,922,555,903	1,937,900,887	1,209,614,818	1,209,061,040	505,586,098

(a) Included in "Other States." [1]*Eng. Min. Jour.* [2]U. S. Geol. Surv.

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The table gives the production of so-called blister copper, or converter copper, in part marketed as such, but mostly sent to electrolytic refineries before going into the hands of consumers. The 1921 smelter production is compared with pre-war, war, and post-war production in the following table:

SMELTER PRODUCTION OF UNITED STATES COPPER

Year.	Average Monthly Output in Pounds.
1910–1913	96,700,000
1916 (peak)	162,000,000
1919	100,800,000
1920	114,300,000
Jan., 1921	90,600,000
Whole of 1921	42,100,000

SMELTERS' PRODUCTION SINCE 1916—DELIVERIES TO REFINERIES (a)
(In pounds)

Source.	1917.	1918.	1919.	1920(b).	1921(b).
North American ore	2,161,627,729	2,235,596,681	1,448,228,759	1,209,061,040	505,586,098
Foreign ore	74,410,422	31,128,156	26,788,765	116,437,055	.....
Scrap	41,821,811	41,854,309	28,127,102	.....	.....
Totals	2,277,859,962	2,308,579,146	1,503,144,626	.....	.....
To foreign refiners	33,261,435	33,789,554	24,878,520	.....	.....
To American refiners	2,244,598,527	2,274,789,592	1,478,266,106	.....	.....
Crude copper imported	274,813,001	256,921,478	(b)263,220,449	244,696,324	174,560,177
Total crude copper	2,519,411,528	2,531,711,070	1,741,486,555	.....	.....

(a) *Eng. Min. Jour.* (b) U. S. Geol. Surv.

PRODUCTION OF REFINED COPPER BY REGULAR REFINERIES (a)
(In pounds)

	1916.	1917.	1918.	1919.	1920.	1921.
Primary (b):						
Domestic—						
Electrolytic	1,579,620,513	1,452,744,593	1,560,327,422	1,233,994,324	1,010,240,867	506,532,984
Lake	269,794,531	268,508,091	231,096,158	177,594,135	153,483,952	100,918,001
Casting	12,469,050	69,916,911	15,284,635	18,223,145	13,905,114	1,740,393
Pig and best select	26,868,105	82,376,576	76,165,976	3,674,191	4,793,307	222,878
	1,888,752,199	1,873,546,171	1,882,874,191	1,433,485,795	1,182,423,240	609,414,256
Foreign (electrolytic)	370,635,116	(d)555,000,000	(d)492,181,364	370,558,779	450,194,958	405,337,490
Foreign casting and best select	.....	.....	57,329,735	1,262,227	2,290,446	5,275,350
	2,259,387,315	2,428,546,171	2,432,385,290	1,805,306,801	1,634,908,644	1,020,027,096
Secondary:						
Electrolytic	78,585,296	66,337,771	34,674,062	32,408,548	32,856,549	82,017,382
Casting	25,838,511	12,779,125	9,018,049	38,876,481	49,130,510	24,467,951
	104,423,807	79,116,896	43,692,111	71,285,029	81,987,059	106,485,333
Total output	2,363,811,122	2,507,663,067	2,476,077,401	1,876,591,830	1,716,895,703	1,126,512,429

(a) U. S. Geol. Surv.
(b) The separation of refined copper into metal of domestic and foreign origin is only approximate, as an accurate separation at this stage of manufacture is not possible. (c) Some Lake copper was refined at seaboard plants and doubtless marketed under some brand other than Lake. This has been excluded from the Lake copper. (d) Includes refined copper imported.

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Refinery production was 1,020,027,096 lb. in 1921, a decrease of 614,881,548 lb. from 1920. Of this amount domestic refined amounted to 609,414,256 lb., against 1,182,423,240 in 1920; and copper of foreign origin refined in the United States totaled 410,612,840 lb. against 452,485,104 in 1920.

CONSUMPTION

The apparent consumption of new refined copper in the United States during 1921 was 610,988,744 lb., compared with 1,053,838,558 lb. in 1920. The stock held by electrolytic refineries on Jan. 1, 1922, was 459,000,000 lb., compared with 659,000,000 lb. the year previous.

CONSUMPTION OF NEW REFINED COPPER IN THE UNITED STATES

Year.	Production.	Stock Jan. 1.	Supply.	Exports. (b)	Stock Dec. 31.	Consumption.
1912	1,581,920,287	89,454,695	1,671,374,982	775,000,658	105,312,582	791,061,742
1913	1,622,456,829	105,312,582	1,727,769,411	926,441,142	91,348,867	709,979,402
1914(a)	1,533,781,394	90,385,402	1,634,166,796	840,080,922	173,640,501	620,445,373
1915(a)	1,634,204,448	173,640,501	1,807,844,949	681,917,955	82,429,666	1,043,497,328
1916(a)	2,259,387,315	82,429,666	2,341,816,981	784,006,486	128,055,229	1,429,755,266
1917(a)	2,428,546,171	128,055,229	2,556,601,400	1,126,082,417	114,000,000	1,394,829,715
1918(a)	2,432,385,290	114,000,000	2,546,385,290	704,715,714	180,000,000	1,661,669,576
1919(a)	1,805,306,801	180,000,000	1,985,306,801	439,835,229	631,286,567	914,471,572
1920(a)	1,634,908,644	631,000,000	2,265,908,644	553,070,086	659,000,000	1,053,838,558
1921	1,020,027,096	659,000,000	1,679,027,096	609,038,352	742,000,000	610,988,744

(a) U. S. Geol. Surv. (b) Exclusive of manufactured copper.

The copper stock, or unsold primary copper on hand, was 631,000,000 lb. at the beginning of 1921, and 659,000,000 lb. at the end of the year. The new supply of primary refined copper, in hands of refiners on Dec. 31, 1921, was 496,000,000 lb. If we add 297,000,000 lb. of blister copper on hand and copper bars and copper in transit, the total on Dec. 31, 1921, was 793,000,000 lb.,[1] compared with 1,124,000,000 lb. on the first day of January, 1921.

All of the larger copper companies continued operations during the first three months of 1921, but practically all of them shut down about Apr. 1, because efforts to remedy the situation by curtailed production had been unsuccessful, since domestic consumption had fallen to about 90,000,000 lb. per month, compared with 100,000,000 lb. monthly in 1918. This was largely a result of retrenchment in all lines of business, the unwillingness of brass manufacturers and other copper consumers to stock up for the future, a general cessation of building operations, and in part to the use of zinc and aluminium instead of copper.

The general suspension of copper and smelting operations brought production down to 25,000,000 or 30,000,000 lb. per month for the rest of

[1] The U. S. Geological Survey figures are different, being 459,000,000 lb. of refined blister and matte, and 283,000,000 lb. in process, or a total of 742,000,000 lb.

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the year, or a total reduction of 382,000,000 lb. below 1920, because when the larger producers closed down the smelters also shut down and the smaller mines could neither market nor smelt their ores.

Exports

Exports of copper during 1921 were noteworthy, despite the fact that considerable old copper was actually shipped to America from Europe.

During 1921, exports of copper from the United States totaled 628,806,808 lb., compared with 624,053,701 lb. in 1920. This was metallic copper, largely in ingots, wirebars, etc., and does not include the copper content of the brass exported.

The table below presents a summary of copper exports for the past six years, which were of course abnormal owing to the World War.

EXPORTS OF COPPER FROM THE UNITED STATES
(In pounds)

Country.	1916.	1917.	1918.	1919.	1920.	1921.
Ore and matte	5,784,768	5,957,295	3,259,839	668,667	440,906	360,120
Refined ingots, bars, etc. Exported to:						
United Kingdom	173,003,875	372,743,338	251,805,814	105,619,710	99,479,801	62,334,868
Belgium	.....	.....	.....	.....	28,090,450	26,619,837
France	318,136,643	366,231,608	265,270,793	89,188,652	118,489,043	98,731,640
Germany	.....	.....	.....	6,831,400	89,194,588	233,072,479
Italy	98,249,149	152,997,819	121,907,864	65,343,538	918,802	16,369,962
Netherlands	.....	.....	.....	.....	34,228,046	28,646,940
Russia	56,777,486	75,037,925	.....	.....	.....	.....
Japan	.....	.....	33,075	65,595,603	82,913,730	59,170,325
Other Europe	.....	.....	.....	.....	43,420,732	17,158,554
Canada	41,900,063	49,867,577	33,087,082	19,781,227	29,697,098	7,198,649
Other countries	28,549,547	13,901,061	17,923,325	85,800,688	24,794,503	46,813,993
Total refined	716,616,763	1,030,779,328	690,027,953	438,160,818	551,226,793	596,117,247
Blister and black	18,263,118	16,992,357	14,687,823	1,674,411	1,843,293	150,313
Alloys	(c)	(c) 1,228,032	186,260	364,089	454,306	28,916
Old and scrap	815,825	1,070,389	257,403	449,084	577,319	585,111
Pipes and tubes	(c)	(c) 7,260,833	4,109,226	5,993,959	4,899,223	2,250,561
Plates and sheets	24,843,435	42,664,943	19,471,584	13,764,425	22,799,148	5,105,916
Wire, not insulated	23,467,345	26,879,498	15,689,554	55,551,602	41,312,713	11,437,832
Grand total	789,791,254	1,132,832,663	747,689,642	516,627,775	624,053,701	628,806,808

(c) Not separately listed until July 1, 1917.

Over 230,000,000 lb. of American copper was shipped to Germany during 1921, an amount far exceeding the exports to any other country and an amount representing more than 33 per cent. of the outward-bound shipments. The business represented cash payments of more than $30,000,000. France and England have fallen far behind their records of the years immediately preceding. Japanese buying during the past year was not up to that of 1919 or 1920.

Imports

The imports of copper into the United States consist mainly of crude copper, and blister, or converter copper, to be refined electrolytically, but

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there is also some concentrate and a small amount of crude ore sent here to be smelted. The blister copper comes from Chile, Peru, Mexico, Cuba, and some from Canada.

Imports of unmanufactured copper for 1921 totaled 350,472,611 lb., compared with 485,670,691 lb. in 1920.

The copper matte imported during the year amounted to 15,347,626 lb. compared with 17,594,174 lb. in 1920. Unrefined blister copper, as bars, pigs, cathode plates, etc., constituted the bulk of the imports, as usual, totaling 171,735,279 lb.

Copper concentrates imported in 1920 contained 30,774,346 lb. of copper, compared with 46,797,590 lb. in 1920, and imports of ore contained 56,677,948 lb. of copper.

Imports of refined copper, mostly from the Chile Copper Company's works in Chile, amounted to 69,249,281 lb. in 1921, compared with 108,743,298 lb. in 1920.

Imports for the past six years are summarized below.

IMPORTS OF COPPER INTO THE UNITED STATES (a)
(In pounds)

Country.	1916.	1917.	1918.	1919.	1920.	1921.
Ore and matte.						
Imported from:						
Peru	.....	.....	.....	1,470,298	2,076,230	4,119,907
Spain	2,659,211	371,902	.....	2,157,072	2,123,594	5,163,996
Cuba	40,644,140	45,343,462	28,716,903	15,979,585	18,446,649	17,956,447
Canada	37,344,754	31,134,172	31,718,784	28,201,213	28,556,362	3,621,268
Mexico	33,525,559	40,168,291	64,879,683	57,370,307	34,176,192	14,507,374
Chile	44,508,322	43,906,869	18,947,088	15,500,966	18,510,907	41,860,767
Other countries	16,105,868	14,822,411	12,954,023	5,775,622	12,547,121	15,570,161
Total	174,787,854	175,747,107	157,216,481	126,455,063	116,437,055	102,799,920
Blister and black.						
Imported from:						
United Kingdom	1,554,649	.....	112,738	228,083	5,939,811	3,721,557
Spain	550,290	.....	165,011	.....	.....	7,000
Canada	47,951,823	40,571,204	37,881,986	31,199,467	26,287,350	22,073,731
Mexico	61,756,926	40,213,831	83,568,187	52,609,210	72,670,790	16,450,113
Chile	70,762,349	162,227,104	156,285,580	89,859,898	46,289,793	39,242,226
Peru	72,827,909	100,302,275	81,492,209	80,829,505	82,509,806	72,016,068
Portuguese Africa	.....	.....	.....	6,251,788	3,089,470	4,890,520
Japan	9,192,010	6,393,524	827,404	600	.....	.....
Other countries	4,331,359	5,890,018	18,038,556	2,241,898	7,909,304	13,334,064
Total	268,927,315	355,598,036	378,371,651	263,220,449	244,696,324	171,735,279
Refined ingots, bar, etc.	8,411,230	6,751,958	38,087,769	35,138,760	108,743,298	69,249,281
Scrap and old	9,451,388	17,893,594	1,921,539	4,217,340	11,558,367	5,706,896
Alloys	758,193	429,702	207,675	355,982	4,235,647	981,235

(a) The imports reported are the copper contents of ore, matte, and regulus.

World's Production

The total production of copper throughout the world in 1921 was much less than in 1920, being estimated at 533,309 metric tons, compared

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with 945,120 metric tons, equivalent to 1,041,806 short tons, in 1920. In 1920, the different copper-producing countries of the world ranked as follows: United States produced 58.03 per cent. of the world's production; Mexico, 4.8 per cent.; Canada, 4; Chile, almost 10; Peru, 3; Bolivia, 1 per cent.; or a total of 81.7 per cent. by North and South America. Japan's mines added 6.6 per cent.; Australasia, 2.8; Africa, 3.2; Germany, 1.7; and Spain, 2.5 per cent.

The entire European production in 1920 was only 50,000 short tons, or 5 per cent. of the world's total.

THE WORLD'S COPPER PRODUCTION
(In metric tons)

Country.	1914.	1915.	1916.	1917.	1918.	1919(g).	1920(g).	1921(g).
Africa { Cape Co....	3,125	} d27,327	(d)34,572	45,138	31,110	31,350	30,580	39,250
Africa { Namaqua...	2,328							
Africa { Other.....	18,682							
Australasia.....	37,590	32,512	(d)35,000	(d)38,100	33,838	16,441	26,605	18,932
Austria-Hungary.....	3,310	.....	.....	.....	.....	647	1,585	1,000
Bolivia.....	2,743	*3,000	*4,000	*4,000	*4,000	7,000	9,900	9,683
Canada.....	34,027	47,202	47,985	50,626	52,693	36,106	35,500	20,532
Chile.....	40,876	(c)52,081	(c)71,430	83,100	85,850	63,930	94,531	55,721
Cuba.....	6,251	8,836	7,816	10,313	12,337	9,974	6,796	7,802
Germany.....	30,480	25,539	24,796	28,632	15,101	15,775	17,255	16,500
Italy.....	2,410	(c)1,840	(c)1,867	(c)1,248	(c)1,114	(c)1,243	(c)635	(c)100
Japan	68,058	75,415	81,280	111,256	95,800	81,865	66,003	53,392
Mexico.....	36,337	30,969	55,128	47,503	75,529	60,491	45,238	12,316
Norway.....	2,860	2,867	1,162	1,810	2,856	1,800	1,400	1,400
Peru.....	23,647	(d)32,410	(f)41,625	45,260	44,800	39,230	31,276	33,800
Russia.....	31,938	(d)25,881	(d)20,877	*16,000	*5,000	.....	.....	.....
Spain-Portugal.....	37,099	*46,200	*42,000	*42,000	*41,000	35,000	23,000	32,400
Sweden.....	4,692	4,561	3,181	4,423	2,956	3,558	1,289	1,150
United Kingdom (c)..	347	238	282	190	203	146	109	
United States.....	525,529	646,212	881,237	872,065	865,692	(b)583,507	(b)548,418	(b)229,331
Total.....	934,888	1,063,090	1,363,238	(i)1,427,024	(i)1,394,879	(h)993,063	(h)945,120	(h)533,309

(b) U. S. Geol. Surv. (c) As officially reported. (d) As reported by the *Eng. Min. Jour.* (g) Am. Bureau of Metal Statistics, except as noted. (h) Includes 5000 tons estimated production of other countries. (i) Includes 25,000 tons estimated production of other countries.
*Estimated.

WORLD'S PRODUCTION OF COPPER (a)

Year.	Metric Tons.	Short Tons.	Year.	Metric Tons.	Short Tons.	Year.	Metric Tons.	Short Tons.
1887....	226,492	249,716	1899...	476,194	525,021	1911...	879,751	969,750
1888....	262,285	281,179	1900...	491,435	541,561	1912...	1,011,312	1,114,760
1889....	265,516	292,741	1901...	529,508	583,517	1913...	1,002,284	1,104,517
1890....	274,065	302,166	1902...	542,606	597,951	1914...	934,838	1,018,395
1891....	280,138	308,862	1903...	630,590	694,910	1915...	1,063,090	1,171,844
1892....	309,113	340,808	1904...	693,240	764,758	1916...	1,363,238	1,502,697
1893....	310,704	342,562	1905...	698,931	770,221	1917...	1,427,024	1,573,009
1894....	330,075	363,920	1906...	715,510	788,492	1918...	1,394,879	1,537,575
1895....	339,994	374,856	1907...	724,120	798,205	1919...	993,063	1,094,653
1896....	384,493	423,917	1908...	758,065	835,623	1920...	945,120	1,041,806
1897....	412,818	455,147	1909...	854,758	942,408	1921...	533,309	587,867
1898....	441,282	486,529	1910...	877,494	966,998			

(a) The statistics for 1887–1891 are as reported by Henry R. Merton & Co.; 1892–1921 as per MINERAL INDUSTRY.

PRICES

The average price of copper for the year 1921 was 12.9 cts., compared with 18.4 in 1920, 18.6 in 1919, and 24.7 in 1918. The price at the begin-

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ning of January, 1921, was 12.5 cts., or 12.75 cts. producers' price. The price in December, 1921, was 12.1 cts.

The following table shows the monthly average price of electrolytic copper, for each month of the year, for 13 years past.

AVERAGE PRICE OF ELECTROLYTIC COPPER PER POUND IN NEW YORK (a)
(In cents per pound)

Year	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1909	13.893	12.949	12.387	12.563	12.893	13.214	12.880	13.007	12.870	12.700	13.125	13.298	12.982
1910	13.620	13.332	13.255	12.733	12.550	12.404	12.215	12.490	12.379	12.553	12.742	12.581	12.738
1911	12.295	12.256	12.139	12.019	11.989	12.385	12.463	13.405	12.201	12.189	12.616	13.552	12.376
1912	14.094	14.084	14.698	15.741	16.031	17.234	17.190	17.498	17.508	17.314	17.326	17.376	16.341
1913	16.488	14.971	14.713	15.291	15.436	14.672	14.192	15.400	16.328	16.337	15.182	14.224	15.269
1914	14.223	14.491	14.131	14.211	13.996	13.603	13.223	(b)	(b)	(b)	11.739	12.801	13.602
1915	13.641	14.394	14.787	16.818	18.506	19.477	18.796	16.941	17.502	17.686	18.627	20.133	17.275
1916	24.008	26.440	26.310	27.895	28.625	26.601	23.865	26.120	26.855	27.193	30.625	31.890	27.202
1917	28.673	31.750	31.481	27.935	28.788	29.962	26.620	25.380	25.073	23.500	23.500	23.500	27.180
1918	23.500	23.500	23.500	23.500	23.500	23.500	25.904	26.000	26.000	26.000	26.000	(c)	24.628
1919	(c)	16.763	14.856	15.246	15.864	17.610	21.604	22.319	21.755	21.534	19.758	18.295	18.691
1920	18.918	18.569	18.331	18.660	18.484	18.065	18.576	18.346	16.144	15.934	14.257	13.188	17.456
1921	12.597	12.556	11.976	12.438	12.742	12.697	12.170	11.634	11.948	12.673	13.035	13.555	12.502

(a) From *Eng. Min. Jour.* (b) No quotation. (c) No market.

The difference in price between unmanufactured electrolytic copper and copper wire and rolled sheets is shown by the following table, in which copper wire is seen to sell for 4 to 5 cts. a lb. more than electrolytic, and copper sheets for nearly 10 cts. a lb. more than the unmanufactured metal.

AVERAGE MONTHLY PRICES OF COPPER MANUFACTURES (a)
(In cents per pound)

	1918.		1919.		1920.	
	Wire.	Sheet.	Wire.	Sheet.	Wire.	Sheet.
Jan.	26.50	31.50	22.63	29.00	22.81	29.31
Feb.	26.56	31.50	20.19	26.41	23.00	29.50
Mar.	26.43	31.50	17.76	22.78	23.00	29.50
Apr.	26.50	31.50	17.16	22.50	23.00	29.50
May	26.62	31.50	18.00	23.26	23.00	29.50
June	26.64	31.90	20.35	25.34	23.00	29.50
July	29.50	34.25	25.38	31.22	23.00	29.50
Aug.	29.50	34.50	26.46	33.50	23.00	29.50
Sept.	29.50	35.00	26.19	33.50	23.00	29.50
Oct.	29.75	35.25	25.38	33.11	22.65	27.63
Nov.	29.00	35.60	23.63	31.33	20.08	23.73
Dec.	27.70	35.65	21.96	28.50	17.00	22.50
Year	27.85	33.30	22.09	28.37	22.21	28.26

(a) *Eng. Min. Jour.*

The following table gives the average monthly price for 12 years past of standard copper (good merchantable bars) in the London market.

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AVERAGE PRICE OF STANDARD COPPER (G. M. B.'S) IN LONDON (a)
(In pounds sterling per ton of 2240 lb.)

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1910.....	60.923	59.388	59.214	57.238	56.313	55.310	54.194	55.733	55.207	56.722	57.634	56.069	57.054
1911.....	55.604	54.970	54.704	54.035	54.313	56.368	56.670	56.264	55.253	55.176	57.253	62.063	55.973
1912.....	62.760	62.893	65.884	70.294	72.352	78.259	76.636	78.670	78.762	76.389	76.890	75.516	72.942
1913.....	71.741	65.519	65.329	68.111	68.807	67.140	64.166	69.200	73.125	73.383	68.275	65.223	68.355
1914.....	64.304	65.259	64.276	64.747	63.182	61.336	60.540	(b)	(b)	(b)	53.227	56.841	61.534
1915.....	60.756	63.494	66.152	75.096	77.600	82.574	76.011	68.673	68.915	72.601	77.744	80.773	72.532
1916.....	88.083	102.667	107.714	124.319	135.457	112.432	95.119	110.283	113.905	122.750	134.659	145.316	116.029
1917.....	131.921	137.895	136.750	133.842	130.000	130.000	128.409	122.391	117.500	110.000	110.000	110.000	124.892
1918.....	110.000	110.000	110.000	110.000	110.000	110.000	119.913	122.000	122.000	122.000	122.000	118.447	115.580
1919.....	92.238	78.700	76.821	77.300	77.767	83.062	99.576	97.300	100.767	103.418	98.894	103.708	90.796
1920.....	118.095	120.188	109.533	103.025	96.750	87.864	90.148	93.935	96.381	93.327	84.807	75.702	97.480
1921.....	70.964	70.925	67.565	69.381	73.196	71.852	71.155	68.614	67.977	67.327	66.614	66.706	69.356

(a) From *Eng. Min. Jour.* (b) No quotation.

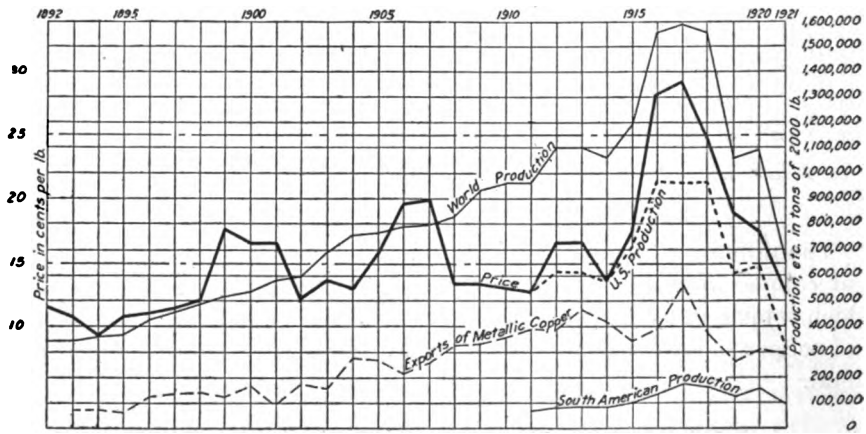

FIG. 1.—Copper production, exports, and price since 1892.

COSTS

The cost of producing a pound of copper varies somewhat at different mines, even when the deposits are similar in type and grade, and the same mining methods are used. There are, however, several general factors which affect all mines equally, such as wages, cost of dynamite, steel, timber, etc.; moreover, in recent years depletion of ore reserves and depreciation of plant have been charged to costs and these items are responsible for a considerable difference in the figures given prior to 1916, compared with the figures of recent years.

A careful study and analysis of the cost of production and average selling price of copper, calculated from official reports and confidential information, was made for the U. S. Geological Survey by H. A. C. Jenison in 1921. Average cost as figured by him included that of mining, milling and smelting, refining, transportation and selling costs, general administration expense, depreciation of plant and equipment,

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Copper Produced in the United States by Principal Mines, 1909–1920, and Average Cost per Pound

Year.	Total Smelter Production.	Production by Principal Mines.							
		Vein Mines.		Lake Mines.		Disseminated-ore Mines.		Total.	
		Quantity.	Average Cost Per Pound.	Quantity.	Average Cost Per Pound.	Quantity.	Average Cost Per Pound.	Quantity.	Average Cost Per Pound.
Pre-war:	*Pounds.*	*Pounds.*	*Cents.*	*Pounds.*	*Cents.*	*Pounds.*	*Cents.*	*Pounds.*	*Cents.*
1909	1,092,951,624	272,830,408	8.97	226,575,286	9.9	154,089,208	9.2	653,494,902	9.34
1910	1,080,159,509	487,289,463	8.2	218,272,734	9.9	205,593,242	8.4	911,155,439	8.61
1911	1,097,232,749	463,322,929	8.8	213,093,306	9.6	263,284,521	8.1	939,700,756	8.78
1912	1,243,268,720	510,801,542	9.0	215,859,751	10.7	314,037,391	8.7	1,040,698,684	9.25
1913	1,224,484,098	492,092,409	10.1	130,487,378	13.8	389,239,696	9.3	1,011,819,483	10.24
1914	1,150,137,192	428,435,453	9.8	159,278,415	11.5	365,445,511	8.3	953,159,379	9.52
	6,888,233,892							5,510,028,643	9.30
War:									
1915	1,388,009,527	557,696,842	9.5	243,802,361	9.6	442,126,316	7.9	1,243,625,519	8.94
1916	1,927,850,548	787,443,989	10.7	259,511,319	12.4	665,469,103	9.3	1,712,424,411	10.44
1917	1,886,120,721	712,239,051	12.2	253,769,681	15.6	680,700,041	12.7	1,646,708,773	12.92
1918	1,908,533,595	723,478,901	13.6	226,901,556	18.9	724,069,192	13.98	1,674,449,649	14.49
	7,110,514,391							6,277,208,352	11.87
Post-war:									
1919	1,286,419,329	408,348,013	14.6	177,463,610	18.4	467,695,747	14.6	1,053,507,370	15.25
1920	1,209,061,040	450,760,285	14.2	153,021,787	18.2	470,250,341	14.6	1,074,032,413	14.94
	2,495,480,369							2,127,539,783	15.09
Grand total	16,494,228,652							13,914,776,778	11.35

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and state and local taxes. Depletion of mine and Federal taxes (income and excess profits) were not included.

For the purpose of the enquiry, 42 mines were considered. The ore-bodies of these 42 mines are of different types, and belong to three natural classes: The Lake group or native copper mines of Michigan included 20 properties; the vein or replacement group consisted of eleven mines, including the Butte, Montana, Bisbee, and other great mines; the remaining eleven were disseminated or so-called porphyry properties. According to this author "these 42 mines represent so high and constant a percentage of the total smelter output of the United States that their average cost of production is doubtless fairly close to the average for all mines. Furthermore the changes in the average cost by these mines have for some years been quickly reflected in the average price, and vice versa, indicating that these mines dominate the American copper industry."

The table given on the preceding page summarizes the work of the investigation. .

Though not actually an operating cost, depletion charges constitute a reduction of assets, and should be deducted from operating income. This item probably averages 3 cts. per lb. This, together with Federal taxes and the cost of deferred development work, should therefore be included in the calculations and absorb part of the difference between average price and average cost, the balance being profit.

Copper Mining in the United States

As already noted in discussing the copper-mining industry as a whole, the year 1921 was the most unsatisfactory one that the mines of this country have ever experienced. Not only was operating revenue completely shut off for most of the mines during three-fourths of the year, but there was an operating loss for the first three months, after which heavy maintenance expenses had to be kept up at most properties to prevent the workings being flooded, caved shut, or seriously damaged. There was, therefore, a serious inroad into working capital, or into surplus for the larger companies. The effect of this will, however, not be seriously felt until the mines resume operation. The Miami, Kennecott, Copper Range, Quincy, Tennessee Copper, New Cornelia and East Butte companies, and the American Smelting & Refining Co. plants were the only larger producers after the general shut-down on April 1.

Alaska.—It is noteworthy that one-fifth of the entire value of the products exported from Alaska in 1920 was copper, and that nearly all of this was produced by the three mines of the Kennecott Corporation. The copper output in 1921 was 56,214,000 lb. valued at $6,971,000, compared with 70,435,363 lb. in 1920, valued at $12,960,106.

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Production in 1921 was practically all from the Mother Lode-Bonanza mines in the Chitina Basin; the Beatson-Bonanza at Latouche Island, Prince William Sound, and the Rush & Brown mine in the Ketchikan district. Exploration work was continued at the Dickey and McIntosh properties on Prince William Sound and a rich shoot of glance ore found on the Green property on McCarty Creek, Chitina Basin. Production by the Kennecott Corporation was reported at 4,867,520 lb. in June, 1921, or a total for the first six months of the year of 69,758,760 lb., which compares with the year's production of 117,017,340 lb. in 1920.

Arizona.—The State derives no small measure of its prosperity from its copper mines, and the taxes collected by the State and County governments from the copper companies constitute their chief revenue. Aside from the many small properties whose aggregate production is not over 10 per cent. of the 1921 total, the copper mines of the State occur in the following seven districts; Ajo, Bisbee, Globe (and Miami), Jerome, Ray, Superior, and Morenci (Clifton). The total mine output decreased from 558,256,302 lb. in 1920 to 185,034,194 lb. in 1921 and the value from $102,719,160 in 1920 to $23,869,411 in 1921.

Most of the big mines were shut down for nine months of the year, the Miami Copper and New Cornelia companies being notable exceptions. No new copper deposits were found and the development of the lesser mines and hundreds of prospects in the State was practically at a standstill. Eight mines in Maricopa County produced 763 tons of ore yielding 71,177 lb. of copper; 16 in Santa Cruz County yielded 1043 tons of ore with 72,190 lb. of copper; and 13 in Tuma County produced 2413 tons of ore containing 171,384 lb. of copper.

Ajo.—The New Cornelia Co. owns practically all the proven ore-bearing ground of this district, since its acquisition of the Ajo Consolidated holdings. The ores, thoroughly oxidized at the surface, but underlain by sulphides, occur in an oblong pear-shaped mass, bulging at the center and rounding off at the edges. This is 600 ft. deep in the center, lessening to 50 ft. at the edges. The orebody is estimated to contain about 100,000,000 tons of 1.4-per cent. copper ore, exploration to the end of 1920 having given positive reserves of 8,234,460 tons of 1.49-per cent. carbonate ore and 46,000,000 tons of 1.53-per cent. sulphide ore. The carbonate ore furnished the bulk of the 1921 output of 21,150,000 lb. of copper, but work in the 500-ton experimental flotation plant having demonstrated that the sulphide ore can be successfully milled, a 5000-ton plant will be built in 1922. Production is about 1,500,000 lb. monthly when operations are normal.

Bisbee.—The mines of this camp were operated on a small scale

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throughout the year, mining and shipping ore and concentrate to Douglas, even after the reduction works there had shut down.

The Calumet & Arizona mines continued in operation at near normal, until smelting at the company's plant was discontinued on Apr. 18. After that date mine operations were curtailed in order to reduce the output to 15,000 tons of ore monthly and to do about 2500 ft. of development. By Nov. 1 over 100,000 tons of ore was stocked at mine and smelter, and ore extraction was practically suspended. In the year's development about half the work planned to find ore was successful. The Junction shaft was deepened to 2358 ft. and concreted, and as ore extraction goes down but 11 ft. a year, the shaft will serve for many years more.

If the production for 1921 is made to include the recoverable copper in ore stored at the smeltery, the year's total will be 17,297,525 lb. of copper from the Bisbee mines and 575,218 lb. from the 85 mine at Valedon, N. M. During the year 217,069 tons of ore was mined and 185,735 tons was shipped to the Douglas smelter, 19,495 tons to the Copper Queen smelter, and 12,689 tons to Ajo (for sulphur).

The Copper Queen mines at Bisbee produced 143,241 tons of underground ore yielding 18,736,959 lb. of copper and 356,150 tons of steam-shovel ore yielding 11,537,065 lb. of copper. Mine-waters yielded 336,149 lb., making a total production of 30,610,173 lb. for the year 1921.

Underground ore extraction was stopped on Apr. 12, but development work continued to yield a small tonnage from deposits in limestone. Steam-shovel operations were continued until the end of October to remove the overburden of waste precedent to ore extraction. During this 10-month period 29,346 tons of ore averaging 4.67 per cent. copper and 326,804 tons of ore averaging 1.34 per cent. copper were produced by the steam-shovel work.

Mine development for 1921 totaled 57,093 ft. compared with 48,271 ft. in 1920, and ore reserves increased.

The new 4000-ton concentrator power-plant at Bisbee was nearly completed, ready for use in April, 1922.

Globe-Miami.—The mines of these two contiguous camps were not all shut down in 1921, the Miami, Iron Cap and several smaller properties continuing operations. The Old Dominion and Inspiration were, however, closed down the last nine months of the year.

The copper mines of the Globe district contain ores which occur either as lodes in schist, quartzite, limestone, and diabase, or as disseminations in schist and granitic rocks. The ores have been studied under the microscope by Schwartz,[1] who finds that the primary ore consists of pyrite, chalcopyrite, specularite, and bornite, the last named being secondary

[1] *Econ. Geol.*, June-Aug., 1921.

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as well as primary. Oxidation extending down to a depth of 800 ft. and in places 1600 ft. has caused secondary enrichment with chalcocite and many interesting occurrences of oxidized ores. From the microscopical study, it is inferred that the ores show in a convincing manner and with exceptional clearness the common process of replacement, supergine enrichment, and oxidation. A genetic association with diabase is suggested.

The Miami mine was operated throughout 1921, producing 53,311,941 lb. of copper, at a cost of 11.28 cts. per lb., contrasted with a cost of 8.75 to 9.25 cts. in normal times. The property, consisting of 1200 acres of mineral land, was estimated Dec. 31, 1921, to contain 10,733,410 tons of 2.26-per cent. copper ore and 36,000,000 tons of 1.06-per cent. copper ore.

At the Superior & Boston property, over a mile of underground development work and some diamond-drilling was done in 1921. Ore production was stopped by the shut-down of the smelters in April, but production till then (from Sept. 30, 1920) was 11,107 dry tons of ore, assaying 4.37 per cent. copper and 5.88 oz. silver, yielding 970,653 lb. of copper and 65,352 oz. of silver, for which net smelter returns were $95,022.

The Arizona Commercial Co. operated with a loss of $335,336, the metal sales meeting just half the expenses of operation and maintenance. Production was 572,616 lb. of copper, 300 oz. of silver, and 162 oz. of gold.

Morenci.—The mines of this camp did not produce copper in 1921, though development work was continued until April, when the Phelps Dodge Co. shut down all departments and dismissed practically all the employees. In the Autumn, a re-examination of the holdings of the Arizona Copper Co. brought back a considerable number of employees, previous to the taking over of the entire holdings and physical assets of that corporation. Only 2737 tons of ore was mined and no shipments made, but drill work proved the downward extension of the orebodies to the ninth level of the Ryerson mine.

The Arizona Copper Co. sold its entire holdings to the Phelps Dodge Corporation for 50,000 shares of stock of $100 par value, which will constitute 10 per cent. of the Phelps Dodge capitalization, on which 18 per cent. dividends have been regularly paid for 12 years.

The company holdings were so interlocked with those of the Phelps Dodge that further independent operations on the low-grade deposits that must be mined were unduly costly if not impracticable. For the eight months ending May 31, 1921, when the mines shut down, the output was 573,397 tons of 2.15-per cent. ore, concentrated to 7.84 per cent., with a 75.3-per cent. recovery, and producing 80,710 tons of con-

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centrates that yielded 9275 tons or 18,550,000 lb. of copper, compared with 1,046,331 tons of 2.08-per cent. ore in 1920, yielding 35,692,000 lb. of copper.

Ray.—Ray Consolidated, like all the Jackling companies, suspended operations Apr. 1, 1921. Production to that date was 10,110,131 lb. of copper, produced at an operating cost of 16.41 cts. per lb., exclusive of 0.16 cts. per lb. gold and silver and miscellaneous income. Shut-down expenses were $833,136. The total operating income was $1,337,569 and operating expenses, $1,659,062, an operating loss of $321,492, increased by shut-down expense to $1,154,628, which with loss on metal sold gave a total loss taken from surplus of $1,598,318, including $327,421 depreciation charge.

Superior.—The Magma Copper Co., operating for the first three months of 1921, produced 21,445 tons of ore, yielding 2,028,889 lb. of copper, 59,794 oz. of silver and 819 oz. of gold at net cost of 14.9 cts. per lb. of copper, exclusive of depletion. At the end of the year the company held 7,995,233 lb. of copper on hand. During the year 3863 ft. of development work was done, mainly drifting, less than half the usual amount. Ore reserves are stated to be 1,505,000 tons of 5.6-per cent. ore carrying 3 oz. silver and 50 cts. gold per ton. Total production to the end of 1921 is 64,936,585 lb. of copper, 3,011,891 oz. of silver, and 28,050 oz. of gold.

California.—The copper output of California was 11,743,404 lb. in 1921, compared with 12,626,272 lb. in 1920, a very small reduction compared with that of other states.

In the copper belt of Shasta County, the Mountain Copper Co., operating the Hornet mine, has built the town of Matheson, and Keswick has disappeared. The Iron Mountain mine is shut down indefinitely, and the Iron Mountain R. R. is to be abandoned.

The Shasta Zinc & Copper Co., operating the Bully Hill, Rising Star, and Copper City mines, finished its new zinc mill, ran it for six weeks, and shut down until a refining plant could be built. The plant treats zinc-copper-silver ore from the Rising Star mine, where a very large tonnage is developed.

The Afterthought mine at Ingot remained closed down, as the flotation plant could not save the several metals. The Blue Ledge mine in Siskiyou County shut down in June, being one of the last producers to close down. The Balaklala mine was idle, despite its ore reserves, because the Mammoth smelter was shut down; it has been acquired by the United States Smelting, Refining and Mining Co.

The Engels Copper Mining Co. continued development at the Engels and Superior mines and opened 40,000 sq. ft. of ore on the main orebody

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and 6000 ft. to the south of the fault. The production was 1,055,000 lb. of copper in August and 1,046,000 lb. in September, from ore averaging 2.12 per cent. copper with about $1 a ton in precious metals.

Colorado.—The copper produced in the State comes from many small mines, scattered through 17 counties. The aggregate output for 1921 was but 3,660,000 lb., valued at $457,500, a decrease of 383,734 lb. below the 1920 figure of 4,043,734 lb., valued at $744,047. The largest amount came from Eagle County, which furnished 1,446,000 lb., Lake County following with 977,600 lb. and San Miguel with 871,000 lb.

The copper is mainly a by-product, derived from the mining and treatment of silver-bearing ores.

Idaho.—The 1921 output of 1,688,195 lb. of copper valued at $217,777 came from the Empire Copper Co., operating the White Knob mines at Mackay, whose operations were curtailed for half the year to only 1200 tons a month. The Richmond and Snowstorm mines were idle. The 1920 copper output was 2,538,396 lb. valued at $467,065.

Blaine County produced 35,834 lb. from its silver-lead mines; Bonner County, 1304 lb., mainly from the Armstead Mines, Inc.; Boundary County, 125 lb.; Custer County (Empire Copper), 1,215,993 lb., valued at $156,863; Lemhi County, 18,047 lb.; Shoshone County, 404,615 lb.; Washington County, 2432 lb.

Michigan.—The Lake Superior district yielded 80,000,000 lb. of copper in 1921, 45,000,000 lb. being produced in the first three months, and 35,000,000 lb. in the remaining nine months of the year. This compares with 153,483,952 lb. produced in Michigan in 1920 and a record of 269,794,531 lb. in 1916.

Only seven properties were in operation throughout the year, the Calumet & Hecla and its subsidiaries having closed down Apr. 1. Of the seven active properties, but four properties were producers, *viz.*, Copper Range, Quincy, Mohawk and Wolverine; the Seneca, Mayflower, and Arcadian companies did development work only.

The Quincy produced 16,960,265 lb. compared with 19,216,070 in 1920. The company curtailed output by working 4 days instead of 6 each week, until November, when full time was resumed. The ore continued unchanged in depth. Conditions at the Copper Range mines, Trimountain, Champion, and Baltic, continued unchanged, the Trimountain being relatively rich and the Baltic lean, but the rock stamped for all three mines averaged 40 lb. of copper recovered and sold, per ton of ore mined. Mohawk produced about 4,000,000 lb. and Wolverine 4,000,000 lb. in 1921. Arcadian Consolidated resumed sinking at the New Baltic shaft, to drive a level on the 1050 to connect with the New Arcadian shaft.

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A comparative statement of operations covering Baltic, Trimountain, and one-half of Champion, which the Copper Range property embraces, is as follows:

	1921.	Average for Ten Years. 1912 to 1921, Inclusive.
Tons of ore stamped	604,878	890,368
Pounds of refined copper produced	22,310,085	26,290,697
Pounds of refined copper per ton stamped	36.88	29.52
Cost of copper per pound, cents	12.74	11.87
Price received per pound, cents	13.19	19.75
Profit per pound, cents	0.45	7.88
Cost of mining, smelting, freight, marketing	$2,842,196	$3,118,377
Net earnings of Copper Range Co	$235,185	$2,104,890

No dividends were paid in 1921. Dividends to date total $26,998,-345, payments being made in every year from 1905 to 1920 inclusive, except in 1914. Operations were on a profitable basis during the last half of 1921, and conditions are continuing to improve, according to the company's report.

The development at the Seneca has been uniformly satisfactory, and ore extraction was begun in 1922. This company works the underlay of the Kearsarge lode.

The Calumet & Hecla company carried on exhaustive geologic research work in 1921, in both field and laboratory, in an effort to determine useful criteria for mine development as well as geologic conclusions. The detailed production figures for each mine of the State are shown in the following table:

COPPER PRODUCTION IN MICHIGAN
(Pounds of fine copper)

Mines.	1913.	1914.	1915.	1916.	1917.	1918.	1919.	1920.	1921.
Adventure	.....	.....	.....	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Ahmeek	9,220,874	13,643,605	21,800,492	24,142,158	27,919,812	24,851,235	17,223,111	20,489,438	6,255,200
Allouez	4 091,129	6,056,548	10,043,459	10,219,290	8,892,915	7,071,218	3,749,984	2,499,239	*Nil.*
Atlantic	44,370	.....	.....	(*b*)	(*b*)	(*b*)	(*b*)	(*b*)	(*b*)
Baltic	7,736,124	7,001,945	12,028,947	(*b*)	(*b*)	(*b*)	(*b*)	(*b*)	(*b*)
Cal. & Hecla	45,016,890	53,691,562	72,613,320	76,762,240	77,495,283	67,968,357	52,859,146	43,489,643	.....
Centennial	1,612,262	2,287,532	2,347,509	2,367,400	2,002,857	2,492,857	1,365,148	561,284	*Nil.*
Champion	12,080,592	15,807,206	33,407,599	54,747,498	31,268,130	21,748,514	23,082,498	16,951,105	32,669,738
Franklin	1,021,440	93,283	1,314,969	3,116,566	3,155,577	2,827,313	1,062,879	*Nil.*	*Nil.*
Isle Royale	4,158,584	6,593,451	9,342,106	12,412,111	13,480,921	15,442,508	13,007,647	10,621,801	2,491,000
Mass	1,213,545	2,944,952	4,638,452	4,752,588	4,000,000	3,403,827	1,963,178	*Nil.*	*Nil.*
Michigan	.....	.....	.....	.....	.....	1,177,176	1,697,107	1,075,442	*Nil.*
Mohawk	5,778,235	11,094,859	15,882,914	13,834,034	12,313,887	.....	12,850,000	10,269,824	4,054,235
Osceola	11,325,010	14,970,737	19,731,472	19,586,501	16,084,958	15,919,647	.....	7,465,773	*Nil.*
La Salle	287,200	540,731	700,000	1,380,352	1,919,775	.....	340,719	59,713	*Nil.*
Quincy	12,184,128	15,356,380	22,045,813	21,065,612	22,195,577	19,948,965	.....	19,216,070	16,960,265
Superior	2,992,765	3,217,635	4,000,000	3,034,656	2,201,672	1,676,446	563,935	322,871	*Nil.*
Tamarack	4.168,743	1,074,808	3,888,150	6,606,620	.....	.....	.....	*Nil.*	*Nil.*
Trimountain	4,990,938	5,048,306	8,302,896	(*b*)	(*b*)	(*b*)	(*b*)	(*b*)	(*b*)
White Pine	.....	.....	.....	4,207,449	4,067,529	3,273,680	1,979,268	1,850,787	*Nil.*
Winona	1,448,737	1,352,084	1,732,638	2,167,255	1,494,472	19,400,000	561,238	.....	*Nil.*
Wolverine	8,350,312	3,435,459	7,250,866	6,541,492	5,856,889	4,608,865	4,562,617	3,299,086	4,000,000
Victoria	4,488,000	1,486,242	1,499,695	1,661,832	1,612,640	1,533,536	1,245,590	1,060,829	.....
Totals	135,409,566	165,697,325	253,710,422	273,692,525	268,508,091	231,096,158	201,716,335	153,483,952	.....

(*b*) Included in Champion (Copper Range Co.).

The following table shows the dividends paid by Lake Superior producers in 1918 to 1920. No dividends were paid in 1921.

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Mine.	1918.	1919.	1920.	Mine.	1918.	1919.	1920.
Calumet & Hecla..	$5,500,000	$1,000,000	$500,000	Ahmeek....	$2,000,000	$600,000	$300,000
Copper Range Con.	2,366,394	986,016	591,626	Alloues....	600,000	300,000	*Nil*
Mohawk.....	1,000,000	500,000	550,000	Champion..	1,970,720	1,280,000	600,000
Osceola.....	969,200	288,450	96,150	Isle Royale.	375,000	150,000	*Nil.*
Quincy.....	$935,000	440,000	110,000	Centennial.	180,000	*Nil.*	*Nil.*

Montana.—The copper output of the State is practically all from the Butte district, and as the greater properties of that mining center, which are owned by the Anaconda Copper Co., were shut down in March, 1921, the year's output is relatively small. The Butte district outranks all other mining districts of the United States in its total production to date, which at the beginning of 1921 amounted to 7,967,050,000 lb., or 26.91 per cent. of the entire United States production.

Production for 1921 was 48,098,730 lb. of copper, compared with 177,059,260 lb. in 1920. The Anaconda smelters operated for the first three months of the year. The Pittsmont smelter at Butte continued operation on ore from the Davis Daly and East Butte properties until November, when the Colorado mine of the Davis Daly company shut down. The Butte Duluth and Bullwhacker mines were idle throughout the year. The North Butte and Tuolumne stopped ore shipments in March, when the Anaconda smelter closed down.

The Anaconda company's report for 1921 shows concretely the effect of a year of inactivity, and almost complete demoralization of the copper industry. The actual operating loss was $3,188,745, as the metal marketed was sold below the cost of production. The decline in prices of copper, lead, and zinc caused loss or depreciation of inventory of $2,886,637. Interest and depreciation charges amounted to $5,243,699 and $2,568,503 was spent for maintenance of property, during the shut-down of nine months, when there were but 1200 men on the pay-roll instead of 13,000.

The total production of copper in 1921 was only 36,257,591 lb. compared with a normal production of about 300,000,000 lb. Sales of metals amounted to $31,097,214 and total earnings to $57,187,636, contrasted with $71,589,791 in 1920. Total costs and charges were $16,999,-555, reducing surplus from $84,753,462 at the beginning of 1921 to $67,753,097 on Dec. 31.

The East Butte company maintained operations throughout most of 1921, producing 87,469 tons of 4.88-per cent. ore yielding 17,766,017 lb. of copper, compared with 18,534,270 in 1920 and 19,987,733 in 1919. Costs were reduced to 11.284 cts. per lb., compared with 15.854 cts. in 1920, 16.582 cts. in 1919, and 19.71 cts. in 1918. Work on the 1800-ft.

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level, the deepest in the mine, shows that the orebodies continue downward with substantially unchanged values and size, much of the ore averaging 7 per cent. The No. 4 shaft is 2000 ft. deep. The company earned a net profit of $150,772 in 1921, compared with a deficit of $68,162 in 1920, and spent $276,798 on outside properties.

At the Butte & Superior property, at Butte, commercial copper ore was encountered on the 2000, 2200, and 2600 levels, which indicates that the dream of the original incorporators may yet be realized, and that the Black Rock may also be classed as a copper mine, as well as being one of the greatest single zinc producers of the world. During the years 1913 to 1921 the company has paid $18,642,000 for labor and $8,500,000 for supplies, and has mined and milled 3,442,942 tons of ore.

During the three months in which ore was mined, the output of the Tuolumne company from its Main Range mine was about 50 tons per day,—4129 wet and 3818 dry tons of ore of an average assay value of 2.9599 per cent. copper, with 8.26 oz. silver and 0.0075 oz. gold per ton, yielding 218,827 lb. of copper with net smelter return of $30,020. Development work was vigorously continued during the entire year, and the shaft deepened 350 ft., or down to 1600 ft., with 927 ft. of crosscut work and 950 ft. of drifting, exposing irregular mineralization by rich stringers on the Spread Delight vein.

Nevada.—The mines of the State produced 10,961,491 lb. of copper in 1921, valued at $1,414,232, compared with 50,559,763 lb. valued at $9,302,996 in 1920. This came almost entirely from the mines of the Nevada Consolidated at Ely, though these mines shut down in April, except at the Ruth where first-class ore was mined and stocked. The Mason Valley and other mines at Yerington were closed down, and the Copper Basin mine near Battle Mountain was under development only.

New Mexico.—The mines of the State produced 14,267,338 lb. of copper in 1921, compared with 54,500,691 lb. in 1920. The Burro Mountain branch of the Phelps Dodge Corporation, owning the mines at Tyrone, was shut down Apr. 1. The Chino company, operating its mines at Santa Rita, produced 9,137,282 lb. of copper compared with 46,088,609 lb. in 1920. The production for the first three months of 1921 was 8,913,405 lb.

Oregon.—The mines of this State yielded 274,000 lb. of copper in 1921, a decrease of 88 per cent. compared with 1920, due to the closing down of the Cornucopia and Homestead-Iron Dyke mines.

Pennsylvania.—The Cornwall iron mines in Lebanon County, operated for five months in 1921 by the Bethlehem Steel Co., produced several thousand tons of a low-grade copper concentrate from pyritiferous

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magnetite ore. The concentrate, which was shipped to smelters, contained about 32 per cent. sulphur and 3.36 per cent. copper.

Tennessee.—The mine production of copper in 1921 amounted to 15,084,294 lb., showing only a small decrease from the 16,727,803 lb. output in 1920. The entire output of copper, gold, and silver in the State came from the two large copper mines in the Ducktown district. The Tennessee Copper Co. operated its 2000-ton smelter, converter, and sulphuric-acid plant on crude sulphide ores from the Burra Burra and London mines and the Copper Pyrites Corporation mine at McHarg, held under lease. The pig copper was shipped to the Baltimore Copper Smelting & Refining Co. for refining.

The Ducktown Sulphur, Copper & Iron Co. operated its two 600-ton blast-furnaces and 20-ft. converter on self-fluxing sulphide ore from the Mary and East Tennessee mines, at Isabella. The Mary and Isabella mines (idle in 1921) are opened by 1200-ft. vertical shafts, and the East Tennessee mine by a 700-ft. shaft.

Utah.—The mine production of copper was 30,891,403 lb. in 1921, valued at $3,984,991, compared with 116,931,238 lb. in 1920, valued at $21,515,348. The State's greatest producer, the Utah Copper Co. mine at Bingham Canyon, was closed down in April after producing 25,000,000 lb. since the beginning of the year. The Utah Consolidated was closed in March. The U. S. Mining, Montana Bingham, and Tintic Standard continued operation, but their production was small, coming mainly from silver ores.

Washington.—The 1921 output of the copper mines of the State was but 251,544 lb., compared with 1,983,134 lb. in 1920. The 1921 production was mostly from the United Silver Copper Co.'s mine near Chewelah, the Sunset Co. near Index being idle.

Foreign Countries

The copper mines of the entire world were affected by the lack of demand and low price of the metal, and this was felt as much by the foreign mines as in those of America. In Australia labor legislation, strikes, and market conditions all combined to cause a cessation of mining.

In Russia, under Bolshevik rule, the production was but 0.4 per cent. of normal; the Spanish mines were operated on a small scale. In other European countries the mines, though operated, gave a total output that is not large compared with that of other continents.

South America furnished a large part of the world's supply, as the big producers continued in operation.

Africa.—The greatest copper deposits of Africa, and among the largest in the world, are found in Katanga, the heart of the Congo region,

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in the Belgian Congo. The Tanganyika Concessions, operating the properties through the Union Minière du Haut Katanga, has steadily increased the output from 1,994,000 lb. of copper in 1911, when smelting operations began, to about 70,000,000 lb. in 1921.

The copper occurs largely as malachite impregnations of a sandstone, and the ore is amenable to leaching. In 1921 the company had ten great ore deposits under development, in belts, in a stretch of country extending from near Elizabethville to Ruve. The company reports that the ores so far developed contain 2,000,000 tons of metallic copper, an amount that appears fully to justify the enormous expenditure of capital and the length of time required to make the properties great producers.

The Union Minière now has a regular output of 100 tons or 224,000 lb. of copper daily, and "with the carrying out of the program for the treatment of low-grade ore, the annual production will be increased step by step to over 100,000 tons (or 224,000,000 lb.), which will make it one of the most important of the world's enterprises." The Union Minière holds concession until Mar. 11, 1990, on its mineral rights. The production for 1921 was the largest yet made by the company, being 30,470 tons of copper, comparing with 18,962 tons in 1920, and 23,004 in 1919. The full furnace capacity is 40,000 tons per annum. The new concentrator at Panda, which is to treat 4000 tons daily, was run at part capacity, producing 500 to 700 tons of 20 to 25-per cent. concentrate daily. The electro-leaching test plant of 100 tons daily capacity was put in operation.

Ore reserves of the ten mines of the Eastern group of the Union Minière at the end of 1921 totaled 49,006,000 tons of ore, containing 2,830,000 tons of copper. Extensive drilling and development work now in progress has added to this. At the Western group of mines, active prospecting by drill and underground work has shown 20,000,000 tons of 8-per cent. ore.

At the beginning of 1921 the ten Union Minière mines contained 700,000 tons of 16.50-per cent. smelting ore, 7,100,000 tons of 8-per cent. concentrating ore, 17,700,000 tons of 5.8-per cent. leaching ore, and 6,800,000 tons of 2.3-per cent. sulphide ore, a total of 32,300,000 tons of ore containing 1,869,500 tons of copper. Three mines, the Star, Kambove and Likasi, supplied 164,502 tons, mainly from the Kambove mine, in 1920–21 yielding 18,548 tons of rough copper bars and 414 tons of matte. The company employs 865 Europeans and 11,837 natives. The Union Minière is almost the only industry of importance in Katanga, all others being dependent upon it. The output for the year 1920–21 was lessened by a complete stoppage of work in September and October, 1920, due to a strike of the staff, and also to an inadequate fuel supply.

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A new and important gold-bearing copper deposit was discovered on the Nile Congo Divide Syndicate ground in 1921. The ore is malachite in a silicious lode in porphyry. Native workings over a tract 600 by 3000 ft. contain a pit 30 ft. deep, with lodes up to 20 ft. across. The ores vary up to 42 per cent. copper and $10.75 gold.

The Namaqua Copper Co., whose smelting operations were stopped in 1919, continued development work and installed a converter plant at its smelter. The company's only output was 124 tons of copper precipitate containing 199,360 lb. of copper, sold for £7957, reducing the year's deficit for operations to £13,247. Reserves at the company's four mines, the Homeep, Homeep East, Flat, and Tweefontain, total 111,381 tons of 6.3-per cent. copper ore, besides 68,000 tons of 2.58-per cent. ore in precipitation tanks.

Northern Rhodesia.—This country has been called the Cinderella of the British Colonies, because of its remarkable but undeveloped mineral resources. The copper produced to the end of 1921 totals 7150 tons of metal and 5232 tons of concentrate of a combined value of £899,469.

The copper deposits occur at widely separated localities and are of various types. The copper ore so far mined has come almost entirely from the properties of the Bwana McKubwa and Kafue Copper companies, which were floated by the Rhodesia Copper & General Exploration and Finance Co. The Bwana McKubwa mine, whose wonderful malachite deposits are at N'Dala, near the Congo border, was idle in 1921, but as its reserves are estimated at 3,000,000 tons of 4.5-per cent. ore, and the value can be recovered by flotation, a resumption of operations depends only on market conditions.

At the Sable Antelope mine copper-glance ores occur in a dolomite limestone, the larger bodies at a vertical distance of 50 ft., and the ore is of supergine origin with undoubted evidence of secondary enrichment processes, despite its occurrence in limestone.

Southern Rhodesia.—The copper output in this colony came mainly from the Blockade mine of the Falcon Mines, Ltd., which produced 96 per cent. of the entire 1921 production, or 3079 tons, compared with 3108 tons valued at £333,111 in 1920 and 3012 tons in 1919, valued at £207,470. The Bradleys' Copper B of the Gem Rhodesian Gold Fields, Ltd., produced 96 tons (215,040 lb.). The Odzi Copper, Silverside Syndicate, Denbeighs, Rhodesdale Copper and Rosstock were small producers during the year. At the beginning of 1921, there were 1881 copper claims registered with the Government. They occur in districts, that of Gwelo including 590 "mines," compared with 480 in Lomagundi, 270 in Umtali and 210 in Victoria. The total copper production of the Colony to Dec. 31, 1921, is 241,769 tons, valued at £2,094,661.

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Operations at the Falcon were continued throughout 1921, accompanied by drastic economies, and a cessation of development, but the mine production was 185,783 tons, which reduced reserves 40,000 tons. Metal production for the year ended June 30, 1921, was 184,500 tons of ore treated, that yielded 3140 tons of blister copper, containing 6,912,640 lb. of copper, 35,960 oz. of gold and 69,684 oz. of silver. The mine is 1360 ft. deep with an 1120-ft. shaft, and the reserves July 1, 1921, were 569,000 tons of ore averaging 1.92 per cent. copper and $4.70 gold. The output goes to the United States.

Australia.—Australia produced 18,600 tons (41,664,000 lb.) and exported only 12,082 tons, or about half as much as in 1920. The production for several years has been relatively small, being drastically reduced, many properties closing down in 1921 and others being on the verge of it, owing to a prohibitive cost. This condition is largely due to the unwillingness of labor to accept a reduction of wages. This led two of the largest producers, the Mt. Lyell and Mt. Morgan companies, to announce their inability to continue operations under existing conditions.

The production of the various States of the Australian Commonwealth is summarized in the accompanying table.

More copper is now produced than any other metal in Queensland. The principal mines are in the Cloncurry district, a region where living conditions are quite unattractive and operating costs high, as the field is about 500 miles from the coast, at Townsville. The Cloncurry field covers an area 200 miles long and 40 miles wide, but unfortunately the mines are sparsely scattered over this great area, there being no large groups of mines.

In this district, the Hampden-Cloncurry Co. towards the end of December reopened the Trekelano mine, with the intention of raising 10,000 tons of ore to form a reserve to be utilized when the normal output of the company's mine, after smelting is resumed, fails to meet smelting requirements. A somewhat similar course is to be followed with regard to the Answer mine. The stopes in the Duchess below water-level having become depleted, that mine was closed in June, after 2000 tons of ore had been dumped on the surface. At the Hampden mine, work was confined to keeping the workings clear of water down to the 600-ft. level.

Amongst the Mount Cuthbert group, the only mine on which any attention was bestowed was the Orphan, where the main shaft was deepened to 275 ft. and timbered, and a crosscut driven 16 ft. in the direction of the lode. Work was then stopped for the time being. Enough was not done to decide the question as to whether the lode which had been discovered in the previous year in the level above is a branch of the main orebody or a distinct shoot; however, the mine has a promising outlook.

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PRODUCTION OF COPPER IN AUSTRALASIA
(In tons of 2240 lb.)

Year.	New South Wales.				Queensland.		South Australia.		Tasmania.				Western Australia.		
	Ingots, Matte and Regulus.		Ore.		Copper, Tons.	Value.	Copper, Tons.	Value.	Blister Copper.		Copper Ore.		Copper Ore, Tons.	Copper, Tons. (a)	Combined Value.
	Tons.	Value.	Tons.	Value.					Tons.	Value.	Tons.	Value.			
1912	8,990	£560,025	2,044	£19,766	23,120	£1,698,280	6,295	£461,500	5,136	£430,965	1,392	£9,479	13,607	1,703	£120,154
1913	9,153	595,826	308	2,907	23,655	1,660,178	7,161	488,986	4,560	364,332	1,967	10,932	4,339	82	145,518
1914	3,500	274,671	3	11	18,436	1,118,648	6,881	417,487	7,509	477,361	3,288	18,680	3,913	183	38,173
1915	6,973	.....	*Nil*	*Nil*	19,704	1,428,793	7,725	561,247	7,901	709,167	66	367	737	946	91,169
1916	6,171	.....	*Nil*	*Nil*	19,520	2,265,422	7,279	822,527	6,305	884,689	97	1,765	650	457	4,3335
1917	6,576	714,154	*Nil*	*Nil*	19,062	2,208,232	7,213	902,495	5,845	841,583	771	6,171	966	535	6 85,738
1918	6,510	696,580	*Nil*	*Nil*	18,980	2,087,751	7,169	828,556	5,559	772,162	444	3,944	1,643	478	66,146
1919	1,460	139,296	*Nil*	*Nil*	9,997	952,501	2,517	228,930	5,027	504,961	.....	.....	455	4	10,105
1920	1,290	127,978	*Nil*	*Nil*	15,897	1,551,995	4,339	423,601	4,792	528,237	.....	.....	1,511	137	25,165
1921	.....	.....	.....	.....	2,428	168,556	1,532	106,370	6,181	463,163	.....	.....	.....	.....	.....

(a) Ingots and matte.

The Kalkadoon has been kept in a state of readiness to produce ore whenever it is wanted.

In none of the smaller mines was there any development worthy of particular note, although in quite a number orebodies were opened up which should be capable of yielding large quantities of ore when the occasion warrants an output.

The Empress mine still retains first place as a producer of copper ores in the Herberton field. Work for the year was confined chiefly to sinking the main shaft an additional 100 ft., making the total depth 355 ft. Cross-cutting at the new level is in progress towards the "You and I" lode. The drive is now in 15 ft.; an additional 65 ft. should reach the objective early in the new year and connect with a winze sunk from the 255-ft. level. The winze was sunk on good ore averaging 15 per cent. copper. When the crosscut is completed and levels are driven, several large blocks of ore will be available for stoping.

The Mt. Elliott Co. operates the Elliott mine 70 miles south of the town of Cloncurry and the Mt. Oxide mine 150 miles north of it, as well as several lesser properties. The Mt. Elliott orebody is about 40 ft. wide and 200 ft. long at the surface, lying between slate walls. Oxidation at 230 ft. is succeeded by leaner chalcopyrite ores in bornstone, opened to the 600-ft. level. The company also owns

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the Selwyn mine 20 miles northwest and the Consol mine 20 miles farther northwest.

The State Government took over in 1920 the copper mines known as the Mungana group, near the Chillagoe state smelter, paying a royalty on the output and having the option of purchase if developments proved satisfactory. These mines, with the Einasleigh copper mines, have been the chief source of ore supplies for the smelter. The Mines Department, on behalf of the Government. purchased the mines outright in 1922 and increased the force so that there may be ore enough to keep the furnaces running continuously once they start.

In South Australia the Wallaroo & Moonta company continued operation throughout 1921, mining 49,001 tons of ore from the Wallaroo and 17,525 tons from the old Moonta mine. This yielded 4686 tons of fine copper. These two mines have yielded 726,118,400 lb. of copper valued at £19,765,000 up to June 30, 1920. The ores occur in lodes that are mined to a depth of nearly 3000 ft. and a length of 3400 ft. with over 39 miles of workings at Wallaroo, and a depth of 2500 ft. and for 3840 ft. in length with 40 miles of workings at Moonta. The ore mined for the past 11 years has averaged 3.8 per cent. copper, and has precious-metal values of approximately $10 per ton of metallic copper produced.

Tasmania produced 6181 long tons of copper in 1921, valued at £463,163; this practically all came from the Mount Lyell Co. mines.

New Guinea.—The Debuna and Laloki mines, belonging to the New Guinea Copper Mines, Ltd., are ready to produce ore, the proven reserves being 235,000 tons of 4.5-per cent. copper ore, carrying $2.50 gold per ton, according to Mr. Huntley, the manager. The ore is highly basic, with 40 per cent. sulphur, and is a desirable flux for Australian smelters. About £250,000 has been spent on development, equipment, railway line, and jetties. The company also owns the Mt. Chalmers mine in Queensland.

Canada.—The copper mines of Canada were with one notable exception, the Granby, operated on a reduced scale and shut down in the latter part of 1921. The total production of all the provinces was but 53,461,795 lb. of copper worth $7,459,780 at current exchange, compared with 81,600,691 lb. worth $15,991,982 in 1920, and the high peak of production of 118,769,434 lb. of a value of $29,250,536 in 1918.

Exports of 5255 short tons of fine copper included 1554 tons estimated as recovered from ore shipped to the United States or as contained in copper sulphate.

The copper matte and blister copper produced in British Columbia and Ontario totaled 50,353,645 lb.

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Quebec mines yielded 266,188 lb. of copper from cupriferous pyrite ores, treated for sulphur and subsequently for copper content.

The nickel-copper mines of the Sudbury district of Ontario were practically closed down for half the year and production for the Province was but 12,763,477 lb., all but 118,080 lb. coming from the mines of the Mond, International Nickel, and British America companies. The Mond Co. operated, but on a reduced scale, all year, but the other two closed down in March. Copper ores and residue yielded 27,819 lb. of copper and the South Ontario smelter produced and sold 361,068 lb. of copper sulphate containing 90,267 lb. of copper.

No copper was produced by the mines of Manitoba in 1920, the low price of the metal with high cost of transportation precluding profitable mining operations.

In British Columbia the production was 40,432,130 lb. of copper compared with 45,319,771 lb. in 1920. The Granby company at Anyox operated continuously, and the Trail smelter of the Consolidated Co. handled custom ore as well as the output of its own mines. The Brittania concentrator at Brittania Beach was destroyed by fire and the town wiped out by a snowslide.

In Yukon Territory, ores containing a few hundred thousand pounds of copper were mined but not shipped.

The essential facts concerning the copper exports and imports of the Dominion of Canada are given below, in short tons:

	1920.		1921.	
	Quantity.	Value.	Quantity.	Value.
Exports, copper in ore	23,665	$5,917,782	5,255	$1,029,220
Exports, new metal	20,431	9,412,162	18,166	5,665,298
Exports, copper wire	.....	433,097	.....	569,648
Imports, copper (metallic)	17,954	7,225,244	10,956	3,216,296
Imports, copper ore	1,220	57,640	1,375	48,015

The geology of the copper deposits of the Marble Bay mine, Texada Island, British Columbia, has been described by Dolmage.[1] The ore-bodies, which vary from a few feet to 200 ft. long, 10 to 50 ft. thick and up to 500 ft. vertically, are sharply defined replacements of bornite and chalcopyrite in crystalline limestone above a "stock" of granodiorite. The deposits, like those of the nearby Cornell and Copper Queen mines, are of the typical contact-metamorphic type, but show enrichment by descending surface solutions.

Chile.—The copper produced in Chile is practically all exported, and the official figures for exports are almost identical with production. The

[1] *Econ. Geol.*, Sept.–Oct., 1921, p. 372.

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1921 figures are as follows: Copper bars, 105,064,201 lb. valued at $12,429,-404; copper matte, 713,589 lb. valued at $32,309; copper ore and concentrate 10,715,950 lb. valued at $1,274,092.

These figures show a large decrease below those of 1920, which were as follows: Copper bars, 187,362,529 lb. valued at $34,376,496; copper matte, 8,139,364 lb. valued at $598,983; copper ore, etc., 27,246 tons valued at $934,899.

The figures for bar copper and matte represent a reduction of the actual supply of refined and semi-refined copper in Chile, as production was restricted early in the year. The two largest producers in Chile (both American) went through the year at the lowest possible rate of production that would permit maintenance of organization and of equipment. All other smelters except Catemou and Naltagua were shut down during the year. Most of the output went to Germany.

The Braden Copper Co. operated at reduced capacity throughout 1921, producing 2006 tons of 2.256-per cent. copper ore daily, a total of 732,069 tons of ore during the year, yielding 27,461,691 lb. of blister copper, the lowest in eight years.

The total tonnage produced was only a third of that mined in 1920, but owing to the shutting down of the Fortuna mine, and the higher grade of the ore from the Teniente mine, the grade of ore milled contained 3½ lb. more copper, or 0.178 per cent. more than in 1920. This factor combined with the concentration of mine organization at Teniente gave a decided economy in operations. New development for the year totaled 31,711 ft., or a total to date of 390,940 ft.

The ore mined yielded the best recovery ever produced, averaging 85.58 per cent. of copper content, compared with but 77.28 per cent. in 1920, the concentrate carrying 25.47 per cent. copper with 19.29 per cent. insoluble, compared with 19.49 copper and 20.86 insoluble in 1920.

The company acquired four new claims (49.4 acres) in 1921, making a total of 8217 acres. Ore reserves as of Dec. 31, 1921, amount to 264,510,000 tons of an average copper content of 2.26 per cent.; this includes 184,510,000 net tons of positive ore averaging 2.44 per cent. copper.

The Teniente "C" townsite, housing 400 men, destroyed by fire in 1920, was rebuilt, the Sewall milling plant enlarged, and the new smelter at Calitones finished and a trial run made in January, 1922.

The Chile Exploration Co., the operating subsidiary of the Chile Copper Co., operated throughout the year, producing 54,008,065 lb. of copper, or less than half that of 1920, at a cost of 10.8 cts. per lb. compared with 10.7 cts. in 1920.

Owing to the wet reduction process employed, the company's opera-

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tions are very elastic and can be increased or diminished quickly. In the last half of 1921, the production was about 4,000,000 lb. of copper monthly, and the finished wirebars were produced about 12 days from the time the ore was mined, compared with 90 to 100 days for the industry as a whole.

Cuba.—Detailed returns of Cuban copper production are not available, but the following table summarizes production.

CUBAN COPPER IMPORTED INTO THE UNITED STATES

Year.	Ore.			Concentrates.		
	Tons.	Value.	Value per Ton.	Tons.	Value.	Value per Ton
1912	75,576	$727,229	$9.62	.....	.....	.....
1913	35,905	676,245	18.84	.....	.....	.....
1914	29,177	1,270,182	43.53	.....	.....	.....
1915	61,080	2,680,268	43.88	.....	.....	.....
1916	69,789	4,846,995	69.46	6,900	$381,236	$55.25
1917	86,824	5,824,698	67.10	8,000	469,168	58.65
1918	78,681	4,041,058	51.36	11,540	896,040	77.65
1919	65,001(a)	4,532,648	69.73	.....	.....	.....
1920	58,890(a)	3,020,612	51.29	23,000(b)	.....	.....
1921	52,770(a)	2,809,976	53.25	.....	.....	.....

(a) Including concentrates. (b) Estimated.

The Matahambre mine was the sole exporter of copper in 1921, its exports for the first half of the year being about 8000 tons, increased to 2500 tons of ore and concentrate a month in the last half of the year. The hand-sorted ore averages about 18.5 per cent. copper, and carries 1.6 oz. of silver per ton; the concentrate is about 22 per cent. copper. The concentrator handles 480 tons per day. The Cobre mines near Santiago are still shut down and the mines generally considered worked out, so far as profitable ore extraction is concerned.

Finland.—The Outokumpu copper mines of eastern Finland, which have been small producers since 1914, were leased to German interests in 1921 and will be worked on a greatly increased scale. The mines are about 30 miles from Joensun, and are the most important copper deposits of Finland. The ore is pyritic, consisting of about one-third pyrite and one-eighth chalcopyrite, about 15 per cent. pyrrhotite and 40 per cent. silica. It averages 4 to 4.5 per cent. copper, 27 sulphur, 28 iron, and 10 per cent. zinc.

The ore occurs in a flat layer of quartzite proven by drilling to be 27,600 ft. long, 600 to 700 ft. wide, and 30 to 35 ft. thick.

Japan.—The mines of Japan produced 32,349,960 lb. of copper in the fiscal year 1920–21, a decrease of 2,209,880 lb., according to the *Osaka Government Mining Review.*

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Copper production was curtailed in 1921 presumably in accordance with a well-considered plan to conserve local resources at a time when the metal could be bought at less than cost in other countries. According to a governmental report, the 1920 production was 65,000 short tons and the consumption 82,000 tons; imports amounted to 22,500 tons and exports 5000 tons. The stock of copper on hand was about 27,000 tons at the beginning of 1921, or a little more than in 1920.

During 1921 the domestic demand is said to have averaged 5700 tons monthly and exports to China 1200 tons a month, making a total monthly consumption of 6900 tons against a mean monthly output of 4500 tons, which if continued would soon absorb the 20,000 tons of copper held in existing stock of metal late in 1921.

The five principal copper producers of Japan are the Furukawa, Mitsubishi, Kuhara, Fujita and Sumintorio interests, which combined in 1921 to maintain prices and prevent imports, the combination being known as the Wednesday association.

The following notes illustrate the variety of deposits found in the country.

Besshi ores consist of a fine-grained mixture of iron and copper pyrite with lesser amounts of magnetite and silica. It is a basic pyritic ore devoid of gold or silver. The mine-water passes over scrap iron and the copper is recovered as cement copper.

The Ikuno treats ores from the Kanogasi Olsubichi and other mines that are quartzose and carry galena, blende, and other minerals with gold and silver values.

The Kano orebody occurs in rhyolite near a schist hanging-wall contact. It is a metasomatic replacement, with a wide zone of mineralization, by pyrite, chalcopyrite, blende, galena and silver ores, shown by open cuts 1000 ft. long and 300 ft. wide. They averaged 12 per cent. zinc in 1916.

COPPER EXPORTS OF JAPAN
(In long tons)

	Europe.	America.	China.	Hongkong.	India.	Totals.
1911	17,288	11,009	3,688	.....	2,332	34,307
1912	23,351	6,917	7,317	.....	805	38,390
1913	19,843	5,543	13,320	.....	3,574	42,280
1914	19,642	5,207	13,577	.....	3,274	41,700
1915	45,140	7,800	1,430	.....	1,220	56,000
1916	53,796	2,921	1,577	52	86	58,432
1917	59,070	2,617	4,910	205	3,916	70,778
1918	20,666	37	7,392	1,220	2,427	31,435
1919	2,501	*Nil.*	13,640	1,550	1,371	19,062
1920	655	*Nil.*	4,007	*Nil.*	473	5,135
1921	.....	*Nil.*	.....	.....	.....	9,022

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India.—The copper production of India comes mainly from the mines of the Cape Copper Co., which for many years operated mines in Cape Colony, and from the property of the Cordoba Copper Co., Ltd.

These two companies work the old mines at Rakha just east of Jamshedpur, where a long narrow vein of copper ore runs northwest across the Dalbhum plateau. The Cape Copper Co. developed over 350,000 tons of 3.6-per cent. ore by the close of 1920, and its smelting plant, on the line of the Nagpur railway, produced about 2,688,000 lb. of converter (blister) copper in 1921, and but for a shortage of coal would have produced nearly double that amount. The Cordoba Copper Co., which holds an option on 20 square miles of the Cape Copper Co.'s land, began development operations in 1920 farther west, but did not produce copper in 1921.

Mexico.—The larger copper mines of this country were either idle or operated but part time in 1921.

Official figures of the year's production are not obtainable, the latest being for 1920, when the average monthly production was 4,681,020 lb. and the year's production 46,056,057 kg. (101,323,114 lb.), compared with 50,893,632 kg. in 1919 and 70,223,455 in 1918. Production and export figures are always close together.

Copper exports for 1921 were 15,228,075 kg., compared with 49,192,401 in 1920.

Mexico has 988 copper mines, but the great producers are Cananea and Nacozari in Sonora, Boleo in Lower California, and scattered deposits in Chihuahua.

Greene Cananea, the largest individual copper producer of Mexico, closed down its mines and smelter on Jan. 17, 1921, but during the year development work was continued, plants overhauled, and important changes and additions made to the reduction and power works, improvements which will increase recoveries and lessen operating costs.

Production for 1921 from the company's own ores was 2,025,602 lb. of copper, 93,914 oz. of silver, and 531 oz. of gold. Refined copper cost 14.181 cts. per lb. During 1921 the company sold 18,520,000 lb. of copper to the Copper Export Association. Operations for the year produced a deficit of $2,468,091, of which $493,089 represents expenses during suspension of operations and $1,975,002 loss on sale of metals sold and adjustments of inventories.

The second largest individual copper producer of Mexico is the Moctezuma Copper Co., a subsidiary of the Phelps Dodge Corporation, operating the Pilares mines near Nacozari, Sonora.

The Boleo company continued operations in Lower California throughout 1921

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Newfoundland.—The copper mines on the north shore, which were worked for many years, were not operated in 1921, though development at one property was continued.

Peru.—The Cerro de Pasco company continued to be the only large producer of the country, as it has acquired the entire holdings of the Backus & Johnson Co. The company's output to the beginning of 1921 totaled 660,779,611 lb. of copper, 45,904,700 oz. of silver and 29,825 oz. of gold. In 1921 the mines yielded 56,294,000 lb., or about 6,000,000 lb. less than in 1920, about two-thirds of the maximum wartime production. Present ore reserves (1921) are estimated to give a mine-life of 10 years.

As is well known the company's mines at Cerro are over 14,000 ft. above sea-level, with a bleak and chilly climate, and the smelter operations were hampered by the rarified air and climate conditions. The new plant at Oroya is already in operation, and will operate under far more favorable conditions.

The Quiruvilca copper mines, about 50 miles from Menocucho, the terminus of the Trujillo railway, were taken over in 1921 by a subsidiary of the American Smelting & Refining Co. The mines lie at an altitude of 12,000 ft. and have been small producers for 10 years past, producing about 2000 tons of high-grade ore annually. They are to be equipped with modern plants and hydro-electric power and intensively developed by the new owners.

Russia.—The great copper properties of Russia were unworked in 1921, although the Soviet Republic is reported to have made several attempts to operate the mines. The Far East Republic has given notes on the copper deposits of southeastern Siberia in bulletins issued from Washington, D. C.

Spain.—1921 was a bad year for copper mining in common with that of other metals in Spain and Portugal. Faced with the necessity of lowering prices to get a market for their copper, the producers tried to lower costs with the result of labor troubles, demands for increased salaries, and losses in operating, which resulted in closing down many mines. The exportation of pyrite from Huelva has been curtailed. Exports of copper ore containing less than 2.5 per cent. copper were far less than in 1920, as shown by a comparison for the first 10 months of each year, the figures for 12 months not being obtainable.

To	1920, Metric Tons.	1921, Metric Tons.
Germany	2,089	*Nil.*
Belgium	5,120	7,136
United States	97,732	118,072
Great Britain	129,222	60,683
Netherlands	2,060	7,823

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Copper mining in Spain will undoubtedly be seriously affected by the new export duties of about ¾ ct. a lb. on matte and 2 cts. a lb. on copper ingots and carbonate imposed by the Spanish Government. The exportation of Spanish pyrite, all of which is copper-bearing, has decreased owing to the ending of the war and the greatly curtailed demand for the output of sulphuric-acid plants. The cheap native sulphur produced by the sulphur mines of our own Gulf Coast has reduced the importation of Spanish pyrite from 1,093,000 tons in 1916 to barely 133,000 tons in 1921. The import duties levied on copper matte by France have reduced export to that country.

Sweden.—The geological relations of the copper-bearing pyritic deposits of Sweden and Fenno Scandia generally have been recently described by Geiger.[1] The deposits, though small, are of commercial size; one deposit, that of the Falun mine, was for centuries the world's leading copper producer. The ores occur in rocks of Archaean age which are classed as leptites, rocks originally formed at the surface, but now appearing as very fine-grained gneisses generally of granitic composition, or if less altered as hälleflintas in which the structure of volcanic lavas and tuff may be recognized. These rest on younger granite masses. These rocks are cut by igneous dikes with which the orebodies seem to be associated.

The Metallurgy of Copper in 1921

By L. S. Austin

General Progress in 1921.—Due to the large visible supply, to the drop in price of copper, and to the small demand for it, practically all the larger copper companies suspended operations during 1921. We note in particular the Anaconda, the Utah Copper, the Ray Consolidated, the Chino and the Nevada Consolidated, the Arizona and the Old Dominion copper companies, together with their smelting plants. This occurred because these companies could not then foresee any trend that promised relief from existing conditions. It was reported that this shut-down was a concerted movement in restraint of trade, and so an infringement of the law against the trusts. But since the shut-down was partial, and included independent companies, it can not be contended that the action was due to a common agreement; it was in fact due to compulsion only. With the beginning of the year 1922 an optimistic feeling appeared, due to the cutting down of the visible supply, and to the feeling that with the exhaustion of the large supply of scrap copper and brass, the aftermath of the war, there is bound to be a market that at least the larger companies

[1] *Econ. Geol.*, **16**, No. 4–5 (1921).

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can meet. In spite of the prolonged shut-down of so many smelting plants in 1921, improvement has still gone forward. Notably at the new Cerro de Pasco plant in Peru a good deal of plant construction work has been done.

Broadening the Activities of the Anaconda Copper Mining Co.[1]—The main business of this company in the past has been the production of copper from its mines at Butte. It has carried on all steps, including the production of cathode copper at its own electrolytic refinery. Due to its adoption of copper leaching, it has made sulphuric acid; it used this also for the making of superphosphate for fertilizer, and has gone into the production of electrolytic zinc. It has even overstepped the line into the manufacturing of copper rods and wire. With the experience thus gained, the company has thought it wise to add to its activities by the acquisition of the American Brass Co., Waterbury, Conn., the largest manufacturer of copper and brass products in the United States.

The wisdom of going into the making of rods and wire was shown by the results, for, from June, 1918, to the end of 1921, the wire-mill has had an output of 166,000,000 lb., distributed at a net profit of $850,000, on an original investment of $1,057,000. While the rest of the plants were shut down in February, 1921, the production of the mill was sold ahead for months, and so it has been in continuous operation, and at a substantial profit.

With this experience, and with a view of stabilizing their great enterprise, the company decided to enter the manufacturing field, and to reach out to the ultimate consumer. But it was found that the capacity of present plants engaged in the production of copper products was in excess of possible requirements; so it decided to take over a going concern rather than to build a competing plant. Accordingly the Anaconda Copper Co. acquired control of the American Brass Co., feeling that, had they done so before, they would have placed on the market 20,000,000 lb. of copper and 4,000,000 lb. of zinc per month during the period of the shut-down, have kept their plants in operation, and have avoided the expense incident to closing.

The offer made to the stockholders of the American Brass Co. is that they may exchange their stock on the basis of $150 cash and three shares of Anaconda for each share of American Brass, provided that at least 51 per cent., a controlling interest, is offered. Anaconda shares are selling at about $50, thereby placing a valuation of $300 per share on the capital stock of the American Brass Co.

The following table gives the production of fabricated copper[2] by the American Brass Co. for ten years past:

[1] *Min. Sci. Press*, **124**, 26 (1922).
[2] *Boston News Bureau*, Jan., 1922; *Eng. Min. Jour.*, **113**, 78 (1922).

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	Pounds.		Pounds.
1911	233,839,101	1916	497,324,042
1912	312,461,536	1917	500,790,548
1913	297,253,789	1918	564,853,928
1914	233,961,384	1919	369,591,018
1915	387,059,514	1920	405,178,719
Total	1,464,575,324	Total	2,337,738,255

Both copper and zinc for brass-making are produced by the Anaconda company.

Mining Catalog.—"The Mining Catalog" (Metal and Quarry edition)[1] gives much valuable data pertaining to the metallurgy of copper in its large volume. In particular we draw attention to the following:

An elaborate discussion of the use of the specific-gravity flask, and of pulp constants, is presented, from which can be calculated the various factors used in handling ore-pulps, the specific gravity, the capacity of vats and tanks, and the control of classifiers.

In the description of hydrometallurgical machinery there are illustrated vacuum filters, classifiers, thickeners and agitators. Under head of smelting equipment we find coal-pulverizing plants, sintering machines, blast-furnaces and converters.

For crushing data the reader is referred to articles on the law of crushing, and its applications to crushing machines, notably for jaw-crushers and rolls, including their weight, capacity, and horsepower used. Elsewhere tube- and ball-mills and grinding pans are figured. Conveying machinery and feeders for every use are elaborately shown.

Roasting and Sintering

Roasting.—A. G. McGregor notes[2] the tendency to increase the number of hearths in the multiple-hearth roaster, as described elsewhere in this summary. In this way the ore can be roasted to a lower sulphur content than heretofore before it is necessary to apply extraneous heat. In place of common red brick for the hearths, firebrick is now preferred, laid with high-temperature bonding cement. One notes that in the Queen roaster, elsewhere described, the drop-holes are as large as possible, twice the size of those in the older furnace of the same diameter, and the center drop-holes are as large (50 sq. ft. area). To retain the heat of the calcines, when transferring them to the reverberatory furnace, transfer-car bodies are made in more compact form and the containing-hoppers are heat-insulated, also a non-conducting brick has been added at the lower hearth or bottom of the roaster as well as at the sides. Precautions are taken to cut down the flue-dust loss in transferring calcines and flue-dust to the reverberatory. This is done by the use of a sliding sleeve from hopper to car, and by carefully venting the car.

[1] Keystone Cons. Pub. Co., 1921.
[2] *Eng. Min. Jour.*, 113 ,110 (1922).

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Sintering.—The Cerro de Pasco company plans to add a zinciferous ore to its blast-furnace charge of the composition Cu 2.0 per cent., Zn 12.0 per cent., and Ag 25 oz. per ton. The fines from this ore are to be sintered in Dwight & Lloyd sintering machines before addition to the furnace charge. Ten of these machines are to be installed. Powdered coal, ground and distributed according to the Halbeck system, will be burned.[1] To get better ventilation, and to remove dust more completely from about the sintering machines, the gases after leaving the machines pass through uptakes to cyclone dust-collectors, thence by downtakes and a long flue to the suction fans. Thus the cyclone collector removes the dust and the long flue cools the gas so that it deposits little sulphur on the fan-blades.

The Queen Nine-hearth Roaster.[2]—These multiple-hearth roasting furnaces, evolved by officials of the Copper Queen Reduction Works, Douglas, Ariz., are described by J. M. Samuel. It was the result of an alteration of the six-hearth McDougall roasters, of which there are twenty at this plant. The change was made by an extension upward of 2 ft. 9 in. on the 18-ft. shell of the furnace, while the hearths were crowded and made thinner.

Fig. 1 is in part a section, in part an elevation of the Queen nine-hearth roaster, giving details of its feed, gas outlet, rabble-arms, air-pipes and doors.

In planning the furnace, the shell was heightened by 2 ft. 9 in. in order to permit addition of three hearths. In roasting, sulphur was to be eliminated at the rate of 30 lb. per sq. ft. per 24 hr., and the exit gases were to carry 5 per cent. of sulphur dioxide by volume, while, by increasing the port openings, the velocity of these gases was cut to 10 ft. per second. This lower velocity ensures a good air supply; accretions about the air-ports form slowly, and so diminish the labor and discomfort of removing them; also less flue-dust is made. The port openings were increased to 50 sq. ft., needing increased care in providing such an area in an 18-ft. furnace. To diminish radiation losses of the calcines the bottom hearth was made of non-conducting Kieselguhr brick, the side-walls were likewise thus lined, and the space between hearths was cut down to 19 in. Referring to Fig. 1, the arch of the hearth is given a rise, and the thickness tapers from 8 in. at the periphery to 4 in. thick at the center. Also the rabble-arms of 6-in. pipe are set neatly to clear the hearths by 3½ in. above the rabble-arm, and the same below the rabble-blades. The furnace top is of cast-iron plates and the gas outlet, 3 ft. 9 in. in diameter, also of cast iron, leads to the outlet-flue above. For feeding the ore, the hopper at the right has a steel plate-shelf set just

[1] See MINERAL INDUSTRY, **28**, 199 (1919).
[2] *Trans. Am. Inst. Min. Met. Eng.*, Paper 1079-N (1921).

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below its bottom opening. Ore is raked off this by a scraper on one of the six top arms, and falls upon the cast-iron top, to be distributed by rabble-blades 12 in. wide, set at an angle of 20°, that cut through the

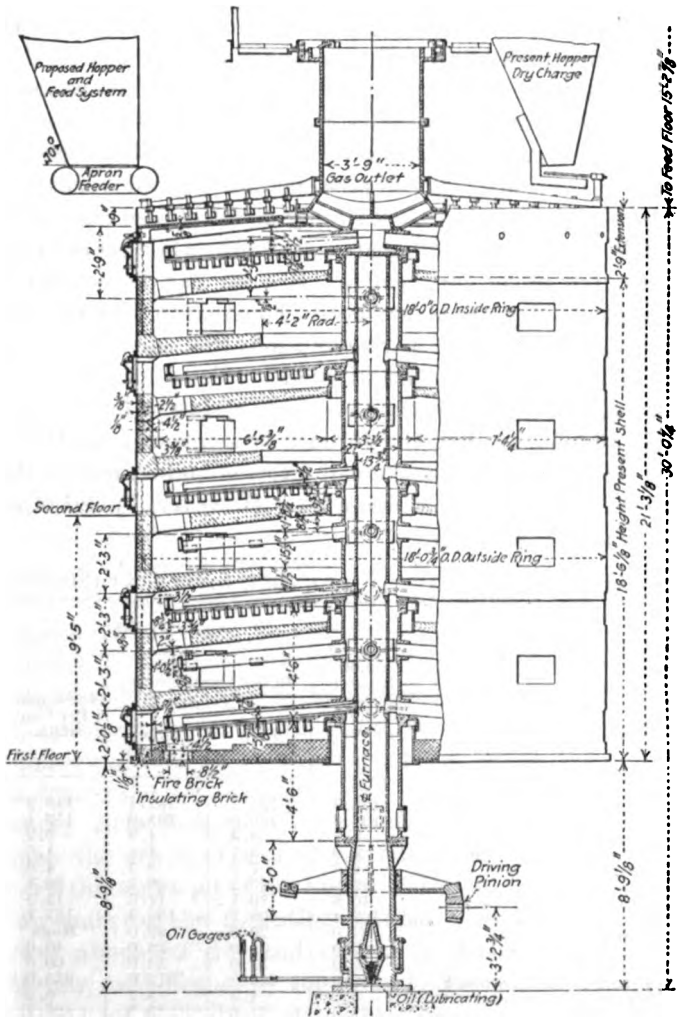

FIG. 1.—Queen nine-hearth roaster.

layer of ore on the furnace top to prevent its caking, and likewise traverse it to the central feed-opening.[1] The furnace shaft, 27 in. in diameter, has an inner one of 13½ in. Now the rabble-arm has both a 6-in.

[1] An alternate apron-feeder is also shown which by means of a variable-speed drive enables a varying, yet certain feed.

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outer tube and a 3-in. inner one, both extending to the inner hollow shaft, and secured in place by an arm lock-pin. Air for cooling the arms enters the central compartment of the shaft, travels outward to the outer end of the inner rabble-tube, then back between the tubes to a hole opposite the annular space of the central roaster shaft, thus cooling the rabble-arm and itself becoming heated. The arms are equipped with the Repath rabble back tooth, that gives maximum stirring of the ore and uniform ridges across the hearth. Besides the rabble-arms there are two air-arms (6-in. tubes) at each of the three lower hearths, these extending only to the outer shaft. These air-arms are pierced beneath by eight small holes of such size that they supply about 40 per cent. of the air at the drop-hole against the falling stream of ore, while 60 per cent. of the air is distributed along the hearth. Hot air can be wasted from the shaft when the furnace gets too hot. The roaster can be operated at any speed from 20 to 55 sec. per revolution, the higher speed increasing oxidation, due to more frequent stirring.

The subjoined table shows that when a charge low in moisture is roasted, (1) the capacity of the furnace is increased; (2) the calcine is hotter; (3) sulphur dioxide in the exit gases is higher, due to their lesser volume; and (4) there is more flue-dust. However, by aid of a Cottrell treater, all this dust is caught.

QUEEN ROASTER, DAILY AVERAGES UNDER DIFFERENT CONDITIONS

	Original Design of Roaster, Estimated Performance.	Capacity Tests.			Sweet Roast Test, 30 Per Cent. Slimes.
		30 Per Cent. Slimes.		No Slimes, 6 Per Cent. H_2O.	
		High Moisture.	Low Moisture.		
Dry charge, tons	123.9	125.2	182.1	146.2	125.1
Wet charge, tons	137.3	136.6	191.0	156.1	130.6
Water in feed, per cent	9.8	9.3	4.9	6.2	4.3
Water removed by top dry, per cent	7.0	2.1	1.4	1.6	1.3
Water into furnace, per cent	2.8	7.2	3.5	4.6	3.0
Sulphur in feed, per cent	27.2	25.2	28.2	28.4	27.2
Sulphur in calcines, per cent	10.8	10.1	11.6	12.5	6.3
Calcines produced, tons	107.4	108.7	158.3	127.1	108.4
Slimes in feed, per cent,	39.0	29.0	29.0	None	25.0
Sand conc. in feed, per cent	12.0	32.0	28.0	40.0	25.0
Crushed ore in feed, per cent	49.0	39.0	43.0	60.0	50.0
Temperature of outgoing gas, degrees F	600.0	564.0	673.0	635.0	762.0
Sulphur dioxide in outgoing gas, per cent	5.0	4.3	8.7	6.2	7.8
Sulphur eliminated, tons	21.9	21.6	35.3	26.7	27.9
Temperature of calcines, degrees F	1300.0	1183.0	1358.0	1324.0	1321.0
Dust produced, per cent. of charge	.....	4.9	13.1	4.6	12.1
+ ½-in. diam. in charge, per cent	None	22.0	9.4	13.5	9.0
Time down barring, per cent	.....	0.3	7.0	0.4	5.0
Oil used, cents per ton	None	5.2	None	None	None
Draft, inches of water	0.25	0.11	0.14	0.13	0.12

In general a multiple-hearth roaster works best when the exit gases contain about 5 per cent. of sulphur dioxide. The Queen roaster, how-

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ever, has been operated to maximum capacity when making gases containing 10 per cent.

Theory of Roasting Sulphide Ores in a Multiple-hearth Roaster.—The crushed ore, of minus ¼-in. size, is traversed and stirred, and particulary as it falls through the drop-openings is subject to ascending air-currents. Roasting proceeds by three stages, *viz.:*

1. Upon the cast-iron top and at the upper hearth the ore is stirred, heated, and dried.

2. The driving-off of the first atom of sulphur, and its burning to SO_2 by contact with the air in the rising furnace-gases. To do this a temperature of 415° C. or above is needed, and the ore should be crushed to ¼-in. size or less.

3. Oxidation of the remaining atom of sulphur, and of the iron with which it is combined, takes place on the lower hearths with the formation of sulphur dioxide, and ferrous and ferric oxides. In this the law of mass-action is followed and the reactions speed up with increasing air brought intimately in contact with the ore at high temperature. But the more the air the more the lower hearths are cooled. The heat goes away (1) in the exit gases, (2) in the calcines, and (3) by radiation. The temperature of these gases for a given furnace-design is fairly constant, and may be calculated as the product of their weight into their specific heat. The incoming air takes heat from the burning ore, and though of lower temperature than the ore gets more highly heated as it rises from hearth to hearth. The heat taken away by the calcines is a small item, and yet this product should be transferred as hot as possible to the reverberatory that follows. Furnace radiation loss should be kept down by non-conducting linings, though such radiation to the top hearth is utilized in drying the ore there delivered.

Moistening Blast-furnace Air.[1]—J. H. Gillis describes experiments to determine the effect of moistening the blast-air of a copper-nickel furnace. To this end a jet of dry steam at 180 lb. pressure was admitted into the air-main of the operating furnace. The temperature of the blast-air was about 80° F., and enough steam was admitted to just saturate the air, as indicated by some condensation of moisture at valves and joints. About 8200 lb. of steam was used at a cost of $7.20 daily. For the two days of the test, tonnage was increased 14.7 per cent. over the average of five days preceeding, and greater than had previously been possible. Mr. Gillis is of the opinion that such addition of moisture would likewise result in a saving in coke and flux and in smoothness of operation. The furnace was 50 in. wide by 30 ft. long at the tuyere-level, and was smelting raw pyrrhotite ore with converter slag as flux.

[1] *Eng. Min. Jour.*, **112**, 251 (1921).

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Nodulizing Flue-dust and Fine Ores for Blast-furnace Use.[1]—The process as practiced at the smelter of the U. S. Metals Refining Co., Chrome, N. J., is described by C. L. Colbert, the smelter superintendent.

A sectional elevation of the discharge-end of a 60- by 7-ft. revolving kiln is shown in Fig. 2. The material, fed through the cylinder at the rate of 80 or 90 tons daily, is heated to softening temperature by the time it arrives at the discharge-end. There is a red heat not farther than 10 to 12 ft. from this end, with a bright red heat at the outlet. The semi-plastic material drops through the discharge-chute to the corrugated rolls, the larger one a fixed roll with deep flanges, the other a movable roll, fitting between the flanges, and pressed forward by a weighted lever-

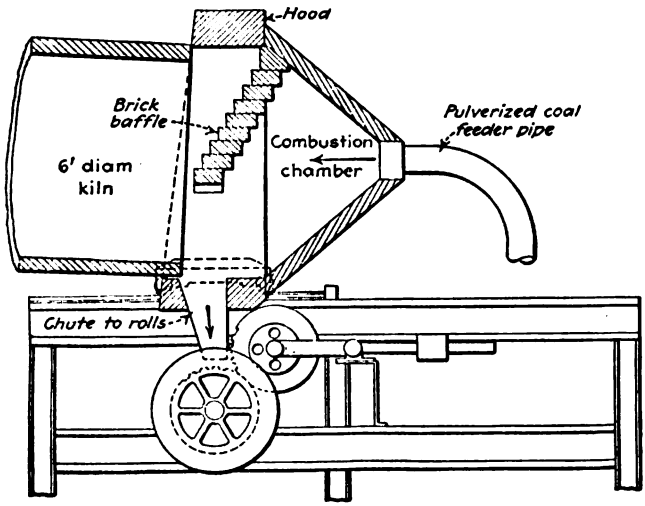

FIG. 2.—Discharge-end of nodulizing kiln, U. S. Metals Refining Co., Chrome, N. J.

arm. There results a ribbon 4 in. wide and ¾ to 1½ in. thick, also about 5 per cent. of unpressed fines. Due to the roll-corrugations the ribbon breaks up into pieces about half the size of an ordinary brick. The drive for the fixed roll should be by means of a variable-speed motor for quick adjustment to suit the kiln-feed.

As shown in the figure, there is provided a conical combustion chamber having a baffle-wall for the distribution of the flame, and where pulverized coal is burned, its combustion is perfected before it enters the kiln. In the older way of using the kiln as a combustion chamber the flame was sharpened, and the region of intensest heat was toward the feed-end. At this point a ring of fused material attached itself to the interior brick-work of the cylinder, so that it had to be shut down from time to time to

[1] *Eng. Min. Jour.*, **112**, 255 (1921).

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cut or bar off the accretions, resulting in serious delays. It was possible to minimize this trouble by skilful firing, but with an output of but 30 to 40 tons per day. The consumption of powdered coal is now 70 lb. per ton of agglomerated material, and where oil has been used, the same result is attained with 10½ gal. of oil. The coal used carries 3 to 6 per cent. of moisture, and is ground and screened in a short rotating screen, so that it is much coarser than such coal at other plants where it is customarily dried and crushed mostly to 200-mesh size. Some successful work has been done by use of a portion of buckwheat-size anthracite, which is a cheaper product. Due to the more diffused heat employed, there is less elimination of sulphur as compared with the results when using a direct flame, this retention of sulphur in the product being desired. The flue-dust as charged contains 7 to 9 per cent. sulphur, and the nodules 4 to 5 per cent.

It is to be noted that for a flotation concentrate, high in sulphur, iron, and copper, a shorter kiln would be better, the material being then more fusible than that here treated. Flue-dust low in sulphur, or concentrates needing more roasting, call for a longer kiln and more revolutions per minute.

The Sizing of the Blast-furnace Charge.[1]—It has been customary to feed run-of-mine ore to the blast-furnace under the impression that the larger pieces would conduce to making the charge more open, but J. H. Gillis in his article takes another view. He gives an instance where the first crushing through the primary crusher, set at 8-in. opening, gave a product with slabs as large as 18 in. long by 12 in. wide. The ore was again crushed to pass a 4-in. grizzly. When the product from the coarse crusher, with its large lumps, was alone used, it was found necessary to increase the amount of coke on the furnace by one-fifth. When, however, the finer product alone was used the coke was again reduced. Moreover, there were other advantages secured, the increased oxidation of the sulphide ore, little formation of crusts and accretions, and increased tonnage put through. The greater elimination of sulphur meant a higher grade of matte, and so less of it to be handled. Also, with the use of the finer crushed ore, it was more easily and readily handled through the plant. It can be seen that judicious crushing, with the production of little fines but with the larger pieces crushed, really gives an open charge and more surfaces exposed to the action of the heated gasses.[2]

When an ore is made into screen-sizes, the fines weigh more than any other size, but the unscreened ore again is heavier. It may, therefore,

[1] *Eng. Min. Jour.*, **112**, 175 (1921).

[2] Twenty years ago I observed the same improvement in silver-lead smelting practice due to the crushing of the limerock to minus 2-in. size. Some operators, however, claimed that large pieces of limerock should be fed to make the charge more open. As such pieces descended with the charge into the hotter zone of the furnace they cracked open, due to the escape of the contained CO_2 gas. L. S. A.

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be contended that for giving a more open charge, each screen-size should be separately charged, followed by the fines as a separate layer.

Jacket-scale Elimination.[1]—To prevent the formation of scale by the jacket-water of a blast-furnace at Broken Hill in Rhodesia, South Africa, bundles of wattle bark were placed in the hot-well that receives the jacket-water. About one ton monthly is thus used, the tannin in the bark ensuring the reduction of the scale to a minimum. During two years past no jackets have been burnt out as the result of scale formation, and so one cause of stoppages has been cut off. In other districts tannin-carrying barks can be similarly used.

Recovery of Metals in Smelting.—E. P. Mathewson states that a great deal of attention is now paid to the recovery of by-products in smelting operations. Under this head the following may be mentioned: Sulphuric acid, liquid sulphur dioxide, gold, silver, lead, zinc, zinc oxide, zinc dust, test lead, blue vitriol, litharge, cadmium, bismuth, thallium, selenium and its compounds, tellurium, arsenic, fungicides, insecticides, phosphate fertilizer, aluminium and its compounds, antimony, lithopone, platinum, palladium, iridium, nickel and its compounds, firebrick, and common brick.

Cost of Copper Production at Mt. Lyell, Tasmania.[2]—By order of the arbitration Court, an expert examination was made, showing the following costs of production:

Gross cost of producing one ton (2240 lb.) of blister copper was £104 11s. 6d., or £4 10s. 1d. less than the company estimate. It was also calculated that the net cost per ton was £95 6s. 3d., and on this basis, with copper at £77, there was a loss of £18 6s. 2d. per ton, equivalent to £95,972 per annum.

Blast-furnace Smelting

Charging.—The new furnaces at Cerro de Pasco will be charged in the same way as those at the Calumet & Arizona plant.[3]

Jacket Cooling.—A. G. McGregor refers[4] to a thermo-syphon water-cooling system, which will operate to cut down the cooling water needed for the jackets. Being automatic in its action it requires but little attention from the furnaceman.

Hot Blast.—At the United Verde plant, Clarkdale, Ariz., the blast-furnaces have Giroux hot-blast tops, which increase the temperature of the blast-air by 40 to 65° C. (A. C. McGregor says 75° C.). It is planned to improve this by the use of a system that will take more heat from the furnace-gases, and so deliver a more highly heated blast-air.

[1] *Eng. Min. Jour.*, **112**, 90 (1921).
[2] *Eng. Min. Jour.*, **112**, 191 (1921).
[3] See *Trans. Am. Inst. Min. Met. Eng.*, **55**, 788 (1916).
[4] *Eng. Min. Jour.*, **113**, 112 (1922).

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Sulphuric Acid from Blast-furnace Gases.—At Copperhill, Tenn., the blast-furnaces are run pyritically, yielding a gas containing about 7 per cent. SO_2. So well is sulphur eliminated that 90 per cent. of the contained sulphur of the ore is thus gasified, and of this the sulphuric-acid plants recover 92 per cent.

Reverberatory vs. Blast-furnace Smelting.[1]—In the Southwest (Arizona and New Mexico), taking into consideration the cost of fuel-oil or powdered coal for the reverberatories, as compared with the cost of coke for the blast-furnaces, the reverberatory has the advantage. Under this condition, and due to the further fact that much heat is recovered in the waste-heat boilers, the advantage is with the reverberatory, even when one considers the added cost of crushing and roasting the ore for them.

Discussing their comparative merits, E. P. Mathewson[2] states that the blast-furnace still holds its own in smelting sulphides. Where concentrates are to be so smelted, it has been found cheaper to sinter them than to roast them. Also, while the blast-furnace can take any kind of ore, provided cheap fluxes are available, the reverberatory should be provided with as nearly a self-fluxing concentrate as possible.

As respects fuel used, some recent experiments indicate that pulverized coal can be partly substituted for coke in blast-furnace operation, so competing with this fuel as used in the reverberatory.

A large field is, however, left for the reverberatory in smelting both ore and concentrates, especially when a large tonnage of the latter is flotation concentrate. A decided saving of fuel is likewise made by the use of waste-heat boilers.

Blast-furnace Practice, Zimapan District, Mexico.[3]—As described by R. B. Brinsmade, this is an example of a home-made blast-furnace adapted to small operations. It is a round or cupola furnace 39 in. in diameter at the tuyeres, and 4 ft. 6 in. in diameter at the feed-floor. The crucible is made from local rhyolite, and upon it are set the eight jackets, each a 12-in. pipe flattened out to 3 in. capped by plate-iron at top and bottom, and pierced for its tuyere. Above the jacket comes a shaft of stone, 18 in. thick, and surmounted above the feed-floor by a sheet-iron stack. A tuyere-pipe is made up of a 3-in. ell with nipples, one into the tuyere, the other a branch to take the canvas sleeve from an 8-in. nipple on the bustle-pipe. There are eight of these jackets, three on each side with tuyeres, the front and back ones shorter to take the tap-jacket at the front, while the back is bricked up.

The blast-air is supplied at 12 oz. pressure by a Wilbraham blower driven by a horizontal slide-valve engine with cylinder 12 by 15 in., steam

[1] *Eng. Min. Jour.*, **113**, 113 (1922).
[2] *Min. & Met.*, Oct., 1921, p. 13.
[3] *Min. Sci. Press*, **123**, 433 (1921).

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being generated by a 25-hp. boiler. Blowing needs about 8 hp., so that enough power is left for an electric generator to furnish light.

On a charge containing 1.6 to 2.0 per cent. Cu, a matte is produced of 8 to 10 per cent. Cu and 100 to 150 oz. Ag per ton—this meaning a concentration of 5 into 1. The slag and matte together is tapped into 300-lb. slag-pots, and set to cool at the edge of the slag-dump. When cold the matte is broken away from the slag, and shipped by burro and rail to a large smelting works. Due to some arsenic, there is a little speiss formed. This is sent back to the furnace. The slag goes but 0.2 per cent. in copper.

Faster Blast-furnace Running Due to Elimination of the Crucible.[1]—In operating a blast-furnace filled to the tuyeres with a sow, F. K. Brunton found it ran much faster than its companion that had been cleaned out with the tuyeres 20 in. from the bottom. This was confirmed by the performance of two furnaces, each 51 by 360 in., which started with new bottoms in May and an output of 921 tons daily, as against a tonnage in December of 2240 tons, when the crucible had been built up to the tuyere-level by a sow. Again, at another furnace in the southwest United States starting in December with a hearth, he found an output of 5724 tons for the month, but by the following May, when the hearth had filled, the monthly output had increased to 8961 tons.

Forehearth Syphon-tap.[2]—The copper-nickel blast-furnace makes a large yield of about 10-per cent. matte, so corrosive that it soon eats away the matte tap-hole, thus needing renewals that cause delays. A syphon-tap was accordingly devised, consisting of a wall built across near the side of the forehearth to leave an 18-in. space, communicating below by an arched opening through which the matte rose on its way to an overflow spout. When ready for tapping matte the separate slag-flow from the forehearth was dammed back, and the matte overflow opened to fill the matte pot standing ready. When the pot was filled the matte-flow was similarly dammed, and the slag-spout opened. Besides this matte-spout, there was a low-down tap-hole, which could be opened if the forehearth was to be drained. Once a shift this tap-hole was momentarily opened to see that it was in condition to tap easily.

Speedy Spout Replacement.[3]—To lessen the time lost in replacing spouts, E. L. Austin describes the methods used at the Coniston copper-nickel blast-furnaces in Ontario. These are equipped with breast-jackets and with water-cooled, brick-lined trapped spouts. To effect a speedy change a spare spout is prepared, well dried, and just before use laid on top of the hot forehearth. To make the change the furnace is

[1] *Eng. Min. Jour.*, **112**, 404 (1921).
[2] *Eng. Min. Jour.*, **112**, 300 (1921).
[3] *Eng. Min. Jour.*, **111**, 629 (1921).

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tapped, the old spout is disconnected and removed by the aid of a chain-block suspended from a traveling trolley. The spare spout is put in place, bolted on, and the joint grouted, all this taking from 20 to 40 minutes, a great saving as compared with the old way where the spout was set and lined after setting in place.

To repair the matte-tap on a settler (originally 1¾ in. in diameter) when the tap-hole has worn dangerously large, tapping is switched over to the other tap-hole. The old tap-hole is plugged, cooled by aid of an air-blast, and chipped away as far as possible without breaking through. This operation is repeated from time to time until the magnesite tapping-block has been chipped away. It is replaced with a new block, and so is ready to use when the other tap-hole has worn out.

Blast-furnace Smelting of Flotation Concentrates.[1]—An excellent description of small-scale smelting of a copper-bearing flotation product as practiced at the works of the Calaveras Copper Co., Copperopolis, Calif., is given by E. H. Robie of the *Engineering and Mining Journal.* The product to be treated is flotation concentrate which is sintered on a Dwight & Lloyd machine, then smelted in a blast-furnace, that, due to the limited amount available, can be run but five hours out of the twenty-four, the furnace being banked for the rest of the time.

Flotation concentrate in large plants is generally roasted in multiple-hearth furnaces, then smelted in the reverberatory furnace for subsequent converter treatment. When smelted in blast-furnaces the material has been customarily agglomerated by briquetting, nodulizing or sintering. However, flotation concentrates can be dumped wet into a blast-furnace, as at Morenci, Ariz. At this plant a 33-ft. furnace was used, and the smelting done with the addition of a little coarse ore. Much flue-dust was made, but was mostly recovered, and considering the nature of the charge, the furnace did well. Blast-furnaces are not suitable for fine-ore smelting, but if necessary may be run with a low blast, but at a sacrifice of capacity.

Of the methods of agglomeration, briquetting is somewhat costly, does not remove sulphur, and the briquets crumble enough to produce some fines in the furnace. Nodulizing is practiced with success at the Braden smelter in Chile. The most satisfactory way has been by the use of the Dwight & Lloyd sintering machine, especially where sulphur needs to be roasted out. It has been used at the Coniston works, Ontario, and by the Mond Nickel Co., where the sinter mixture consists of fine mine ore, flue-dust and concentrates, and the sintered product is charged to the blast-furnaces.

Referring now to the practice of the Calaveras Copper Co., the prod-

[1] *Eng. Min. Jour.*, 111, 984 (1921).

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uct to be treated was concentrate from the flotation plant. This wet product, coming from the Oliver filter, was delivered to a hopper-bottom bin above the sinter machine. To it was added fines from the sintering operation itself, and the blast-furnace flue-dust. At the bottom of the bin an 8-in. feed-screw feeds to a pug-mill, where the materials are thoroughly mixed and delivered to the feed-hopper of the sinter machine. A heavy feed is given to the machine, the layer being 2 in. deeper than the sides of the pallets (say 6 in. deep).

The Dwight & Lloyd machine is of the standard width of 42 in., and is of 100 tons daily capacity, roasting from 15 down to 8 per cent. sulphur. To maintain this percentage of sulphur the sinter fines are added, and if this is not enough, a little quartz can be substituted, at the same time lessening that fed to the blast-furnace; or again, fine limestone can be used, this also preventing sticking to the grates. A coherent porous sinter is yielded. From the grates this falls upon a grizzly having ¾-in. openings, the undersize of which is returned by a pan-conveyor to the feed-bin, while the coarse, by another conveyor, goes to the blast-furnace charge-bin, and thence is drawn hot to the charge-floor of the furnace.

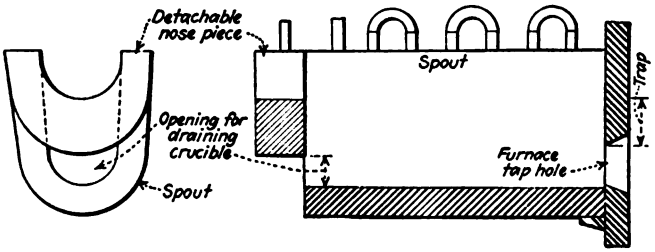

FIG. 3.—Special blast-furnace spout, Calaveras Copper Co.

The blast-furnace of 40 by 120-in. hearth dimensions has ten 5-in. tuyeres per side, and is 10 ft. deep from the tuyeres to the top of the jackets. Alumina is high in this charge, and the furnace is adjusted to smelt 100 tons daily. This is done on one shift, and with a smelting time of 5 hr., and sometimes a day may be skipped, so that the furnace is then idle for 29 hr. Before stopping the furnace, the ore-column is lowered, extra coke is added, and the whole covered with a layer of flue-dust. Since smelting time is so short a small settler is used that will be just full of matte at the end of the day. To tap the furnace properly at the shut-down a special trapped water-cooled spout is used, having a low tap-hole at the bottom of the spout as shown in Fig. 3. This being opened the furnace is drained to the bottom of the crucible. At the end of the day the settler is drained of its matte, but it gradually builds up so that about every three weeks it has to be cut out. It is

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planned with resumption of operations to use portable settlers, so that a fresh one can be readily substituted.

The furnace charge consists of sinter, 2200 lb.; wet flotation concentrate, 900 lb.; coarse sulphide ore, 200 lb.; limerock, 150 lb.; quartz, 150 lb.; with this charge is used 11.8 per cent. of its weight of coke. The analyses of the charge and its products in per cent. are:

	Cu	FeO	SiO_2	Al_2O_3	CaO	MgO	S
Sinter	16	36	18	11	..	5	7
Matte	50	..	..	..	..	..	..
Slag	0.5 to 0.6	36	34	13	6	7	..

Thus 92 per cent. of the charge is ore, and 30 per cent. of it is wet flotation concentrates of 20 per cent. moisture, just as it comes off the filter. This is dumped upon the coke, and is covered with the rest of the charge, and the dust-loss is small. The furnace smelts 10 tons per hr., or 7.2 tons per sq. ft. of hearth-area per 24 hr., with a blast-pressure of 22 oz. per sq. in. Usually four tons of matte is tapped two hours after the furnace starts, and ten tons at the end of the run. It is cooled by water, then crushed to 1-in. size in a small Dodge crusher, sacked, and shipped to the Tacoma smelter.

As outlined above it is more economical to operate this large furnace 5 hr. daily than a small one for 24 hr., or than to roast and smelt in a reverberatory furnace.

Reverberatory Smelting

Size of Furnace.[1]—As the result of experiments conducted at the Copper Queen Smelter, Douglas, Ariz., H. H. Stout advocates making furnaces shorter. Indeed in some, where large tonnages are smelted, they are but 90 ft. long though 24 ft. wide. At El Paso, Texas, there is a furnace 28 ft. wide by 129 ft. 6 in. long. Its capacity is not given.

Skimming.—In plants where a high-ash powdered coal is used, the exclusive practice of continuous tapping does not seem to be practicable. At other plants the present track arrangement is not such that this can be done.

Waste-heat Boiler Connections.—Where the header flue and gas-passages to the boilers are long or complicated, they tend to fill up and clog where high-ash or fusible-ash powdered coal is used, thus needing extra labor to keep them clean. Clean-out doors must be provided and then cold air entering unavoidably cuts down boiler efficiency. Such was the conclusion arising from a six months' experience with the furnaces at the United Verde Extension Co. Accordingly the boilers were raised and moved next to the furnaces, and the connecting flue sloped so that the fused flue-dust in it drained back to the furnace. Sticky particles striking

[1] *Eng. Min. Jour.*, **113**, 111 (1922).

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the boiler-tubes are cooled and drop down to the dust-hoppers below. This change resulted in increasing the evaporation per pound of pulverized coal burned from 3.8 to 4.56 lb. of water.

Draft-control.—At Anaconda an automatic draft-control regulator is provided for the draft from the boilers, thus producing a slight negative pressure in the furnace. This condition prevents cold-air leakage into the furnace, and by cutting the draft to just what is needed for the coal feed, results in a material saving in fuel.

Charging.—At Anaconda the charge-pipes from the overhead hoppers are terminated by water-cooled collars set in the furnace roof, thus assuring a permanent connection. It is realized that present methods of charging are crude. The ore drops through the furnace roof into the highly heated interior. A cloud of dust rises in the furnace, which is carried along by the moving gases, and this dust not only fluxes the exposed brick work, but is swept along into the flues and to the waste-heat boilers, there to be imperfectly recovered. To overcome this difficulty it is planned at Miami to adopt a method of side-charging as follows: The charge will be forced by means of plungers through horizontal charge-holes in the side-walls near the slag line into the furnace. This will bulge out the front surface, protecting the side-wall against the fire. The charging will be intermittent, each new charge forcing outward that previously introduced. Thus the oldest and hottest unmelted charge will form the fusing surface, and dusting will be done away with.

Converter-slag Additions to the Reverberatory Furnace.[1]—When molten slag is poured in the furnace, the falling slag-stream does not properly mix with the molten furnace charge. If, however, the slag-stream is hit by a horizontal jet of high-pressure stream, the slag is granulated and spread over the surface of the charge, and becomes incorporated with it.

Smelting Works of the Nevada Consolidated Copper Co.[2]—This plant, situated at McGill, Nev., is discussed by Arthur B. Parsons as follows:

The smelter buildings are widely spaced, increasing the cost of haulage as compared with a compact plant. Three stacks were built, one for the roasters, 250 ft. high by 18 ft. diameter inside, one for the reverberatories, 300 ft. high by 22 ft. diameter, and one converter stack 90 ft. high by 10 ft. diameter. The provision of three stacks was based on the assumption that two years at least would elapse before the plant would be working at capacity, so that, with a big stack, there would be a period of insufficient draft due to low stack temperatures. Had it been possible to run full, then a large single stack with a compact plant would have been the most profitable. For intra-plant service standard-gauge tracks are used, the hauling being done by small locomotives having saddle tanks

[1] *Chem. Met. Eng.*, **25**, 208 (1912); U. S. Pat. No. 1,378,223, May 17, 1921.
[2] *Min. Sci. Press*, **123**, 393 (1921).

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and with an overall clearance of 7 ft., the load on the drivers being 17 tons. They are fired with coal or, as an alternative, with fuel-oil.

Due to the introduction of flotation the nature of the smelting charge has changed. Thus the concentrate smelted in 1916 contained Cu, 8.0 per cent., SiO_2, 28.4; Fe, 23.9; Al_2O_7, 6.8; S, 27.8; and H_2O, 10.3 per cent., while in 1919 the concentrate, a mixture of the above with flotation concentrate, ran Cu, 8.5 per cent.; SiO_2, 30.7; Fe, 19.8; Al_2O_3, 9.9; S, 23.9; and H_2O, 17.2 per cent.; so that the iron and sulphur had dropped and the alumina increased. This flotation concentrate is a fine, smooth mud in caked form.

Roasting.—To roast the later mixture, the 24 six-hearth 18-ft. roasters were changed to eight-hearth by heightening the shell by 4 ft. 7 in., while the top was made a drying hearth and the gas, as in the Queen roaster elsewhere described in this chapter, was taken off at the center of the top. Air-cooling also replaced water-cooling. The air, under a pressure of 2.9 in. of water, passed up through the center column and out through the rabble-arms, being discharged through holes at the bottom of the arms. This air at once cools the arms, and acts upon the ore as heated air. There are two fans, 84 in. in diameter by 42 in. wide, driven at 360 r.p.m. by 100-hp. motors, and delivering 113,000 cu. ft. of free air per min. Due to higher moisture and lower sulphur, as indicated by the above-cited analysis, the ore takes longer to roast. For handling the large proportions of flotation concentrate on the drying hearth a set of revolving disk-harrows was employed. These cut up the caked concentrates, turning, rolling, and coating them with the coarser table concentrates, thus preventing further agglomeration, while the discs cut clear down to the surface of the top. The older line-shaft drive for the roasters has been replaced by individual 10-hp. motors. The center column has also been speeded up, making one rev. in 35 sec. in place of one in 38 to 55 sec. as heretofore. One may note an area of 23.2 sq. ft. for the central drop-hole as compared with 50 sq. ft. for the Queen roaster. The furnace arches are now made of large specially-shaped fire-tile in place of common brick. The limerock needed at the reverberatory furnaces, about 8 per cent. of the charge, is crushed to ¾-in. size and fed from a special hopper that supplies two adjacent furnaces, the crushed material being fed to the seventh hearth of the roaster, as illustrated in Fig. 4. The plunger feeders formerly used

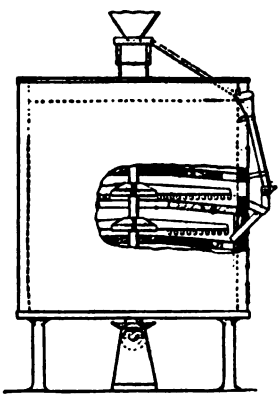

FIG. 4.—Method of roaster feeding to a lower hearth.

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have been replaced by a pan-conveyor feeder, which is a series of drags with chain and sprocket. The thickness of the exuding ribbon of concentrate is regulated by a rack-and-pinion gate at the front of the feed-bin. The mill concentrate is hauled to them in 10-ton hopper-bottom cars, while the calcine they produce is sent to the reverberatory hoppers in 8-ton cars.

The following data are averages covering the operations for the last six months of 1920:

Concentrate roasted per furnace-day, tons	55.9
Limerock per furnace-day, tons	4.7
Total feed per furnace-day, tons	60.6
Sulphur eliminated per furnace-day, tons	11.7
Water eliminated per furnace-day, tons	7.9
Calcine produced per furnace-day, tons	50.78
Sulphur eliminated, per cent	79.5
Pulverized coal used per furnace-day, tons	0.28
Pulverized coal used per ton roasted, pounds	10.2
Pulverized coal used per ton of water evaporated, pounds	72.1

ANALYSIS OF ROASTER FEED, PER CENT.

Copper.	Silica.	Iron.	Alumina.	Sulphur.	Moisture.
8.04	29.0	23.3	7.5	26.3	12.3

Reverberatory Smelting.—Four furnaces, each 121 ft. long by 19 ft. 6 in. wide, are now side-charged as follows: Long charge-bins or troughs are hung from the charge-floor extending over the furnaces near the sides for 50 ft. from the firing end, and where the greatest corrosion occurs. Since the charge-track runs across the furnace, the fine calcines are dropped at one point into the trough, and run like water clear to the further end. From the trough the material is drawn by branch pipes from the bottom as needed into the furnace at the sides, thus protecting the side-walls, and leaving a trough-shaped space for the molten charge. Beyond the 50-ft. point concentrates and fettling are introduced in the usual way. The force of 35 men needed for fettling has been reduced to 10 with side-charging. Below we give two slag analyses, one (A) represents slag made in 1915, and B is a slag typical of 1920. The slag is water-granulated. Roaster flue-dust goes direct to the reverberatories except a portion which collects in the flues near the stack. This carries so much soluble copper that it is preferably leached in a concrete launder, then precipitated in a settling tank by means of scrap iron.

	Copper, Per Cent.	Silica, Per Cent.	Iron, Per Cent.	Lime, Per Cent.	Alumina, Per Cent.
A	0.345	42.6	36.3	10.3	6.5
B	0.40	40.0	29.7	5.5	11.1

The following statistics summarize the operations for the last six months of 1920:

Average grade of matte, copper per cent		39.8
	Total Charge.	Solid Charge
Charge per 100 sq. ft. of hearth-area, tons	25.6	23.5
Gross coal on the charge, per cent	17.6	19.1
Net coal on the charge, per cent	13.2	14.3

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The average proportions of materials in the charge were:

	Per Cent.
Calcine and flue-dust	77.3
Cold secondaries from converters	5.5
Hot converter slag	8.3
Limerock	6.9
Fettling	2.0

The following are typical analyses:

	Moisture, Per Cent.	Copper, Per Cent.	Silica, Per Cent.	Iron, Per Cent.	Lime, Per Cent.	Alumina, Per Cent.	Sulphur, Per Cent.	Magnesia, Per Cent.
Calcine	.....	8.85	31.9	25.6	.....	8.2	5.9	.....
Converter secondaries	.....	28.37	16.8	28.5	1.4	5.8	9.5	.....
Converter slag	.....	1.68	25.7	48.3	0.25	5.0	0.93	0.59
Limerock	.....	.....	1.5	0.3	49.3	0.4	.....	3.3
Fettling	25.8	3.35	45.8	5.4	.....	20.9	5.3	.....

The fettling material consists principally of low-grade flotation concentrate.

Converting.—The 38 to 45-per cent. matte from the reverberatories is tapped into a transfer-ladle, constructed from an old converter shell set on trunnions upon a standard railway truck. This shell, lined with 9 in. of firebrick, is 7 ft. in diameter by 10 ft. long inside dimensions. The ladle is heated by pulverized coal blown in at the trunnions, there being a flexible connection both at the reverberatory and at the converter, so that the contents are being constantly heated except at the time of transfer. The transfer-ladle is brought into the converter-house above the working-floor level, and immediately behind the converters, so that the matte is poured directly into them. Converter flux is charged from boats lifted by the 50-ton overhead traveling crane. The car will hold 35 tons of matte when newly lined, but after six months it builds up inside to 15 or 20 tons capacity, and so must be relined. By this means the converters distant from the reverberatories can be charged rapidly. Two Pierce-Smith horizontal converters, 36 ft. long by 10 ft. in diameter, are used, each having 50 to 60 tons capacity. Each converter has 34 tuyeres with blast-air at 12 lb. pressure. The converter lining is of magnesite brick. These brick are made at the plant, being of old brick-bats pulverized and mixed with fresh raw magnesite in a mud-mill or revolving grinding-pan. The mixture of the pan is moulded into a brick-press at 240 lb. per sq. in. pressure, steam-dried at 90° F., and burned in a 15-ft. beehive kiln fired with coal. The brick are specially moulded to fit the place in which they are to go and are laid in thick magnesite mortar.

A feature of the converter operations is the method of recording the performance on each charge. By means of this record the metallurgist

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is able to determine the efficiency of each step in the operation and to detect delays, faulty manipulation, or failure of equipment. The standards given in the last column below are based upon actual records obtained over long periods under varying conditions and with mattes of different copper content; they become part of the report made on each charge.

NEVADA CONSOLIDATED COPPER CO., STEPTOE PLANT
Pierce-Smith Converter No. 2

	Hours.	Minutes.	Minutes per Ton of Blister.	Minutes per Ton of Iron Slagged.	Standard Minutes per Ton.
Initial bath	1	25	1.7	.....	1.0
Charge, skim, and flux	4	10	5.0	.....	6.5
Blow high	8	10	.....	10.2	12.8
Blow copper	4	15	5.1	.....	5.0
Ladle to receiver	1	0	1.2	.....	1.0
Miscellaneous delays	1	30	.....	.....	1.0
Total	20	30	.....	.....	.....

Matte, tons ..... 148 Matte, per cent. copper 37.1
Tuyeres ..... 31 Tons of blister 49.6
Bars of copper ..... 216 Tons per hour ..... 2.42 Standard 2.41
Ratio to standard ..... 100 per cent.

Air for the converters is supplied by three blowing engines, one of 450 hp. to supply 5100 cu. ft. of air per min., one of 850 hp. to supply 13,500 cu. ft., and the third 950 hp. to yield 15,000 cu. ft.

The Halbeck system of grinding and supplying pulverized coal throughout this works is described in MINERAL INDUSTRY, **28**, 199 (1919).

Coal-pulverizing Plant at the Michigan Smelter.[1]—This works, situated near Houghton, Mich., treats the product of the Copper Range, Mohawk, and Wolverine mines. It has lately installed a coal-pulverizing plant to produce a cheaper and more easily handled fuel for its reverberatory furnaces. This plant has been in operation several months with gratifying results. It has cut coal consumption, so that in place of using 1500 lb. per ton of concentrate, now 525 lb. only are needed. The plant was built at a cost of $150,000.

Large Reverberatory for the Quincy Smelter.[2]—These works, situated at Hancock, Mich., has treated its "mineral" (concentrates) in small furnaces in order to keep individual shipments separate. It intends now to adopt sampling methods, so that such individual lots can be treated as one. For this it can profitably use a large furnace of 150,000 lb. capacity. It will be served by a casting machine, by electric cranes, and a trolley dipping system.

Reverberatory Smelting of Flotation Concentrates at Miami.[3]—In discussing the treatment of this material, half of which runs minus 200 mesh, Walter Broadbridge gives certain details of actual operation.

[1] *Eng. Min. Jour.*, **112**, 674 (1921); *Houghton Gazette*, 1921.
[2] *Eng. Min. Jour.*, **112**, 154 (1921).
[3] Inst. Min. & Met. (British), *Bull.* 184 (Jan., 1920).

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The roaster charge is of the following analysis: Cu, 28.4 per cent.; SiO_2, 16.8; Fe, 16.5; and S, 18.8 per cent. Even this has less sulphur than is needed to produce a 51-per cent. copper matte and so 2 to 3 per cent. of iron pyrite is added. Each furnace is heated by five oil-burners using oil at 75 lb. pressure and air at 12 lb. pressure. Additional air-holes have been put in the roof to make up the supply of air needed to burn the oil above the burners. The matte is tapped at a point one-third the way along the furnace from the burners, while the slag is run off continuously at the front into dump-pots operated by electric locomotives. The reverberatory gases fire seven waste-heat boilers, then pass to a stack 300 ft. high. The Cottrell plant consists of 12 units, each of 20 pipes 13 in. in diameter by 15 ft. long, and a high-tension current of 100,000 volts is employed, the gases traversing the tubes at the rate of 3 ft. per second. Precipitation is practically complete.

Converting Practice

Type and Size of Converters.[1]—As compared with the Great Falls or vertical type of converter, the horizontal Pierce-Smith type is increasingly in use and favored by operators, especially for large plants. The American Smelting & Refining Co. in several of its plants is using the size 13 ft. diameter by 30 ft. long. This is rather large for a plant employing a single converter, since the demand for converter air is quite variable, so causing a fluctuating demand for steam. This steam is generally furnished by waste-heat boilers where it is desirable, on the other hand, to keep a uniform supply. Also, with high-grade matte, the use of so large a converter means that a large charge of blister copper is finished, needing a tilting furnace or an anode furnace to store it between converting and casting. To avoid the use of a tilting furnace the plan of using several smaller converters has been adopted at Cerro de Pasco, using five Pierce-Smith converters, each only 12 ft. in diameter by 20 ft. long. As respects the two types of converters, the Great Falls type up to 16 ft. in diameter has been favored for small plants. Although units of 20-ft. diameter are in use they need careful handling, and are then not so satisfactory as the horizontal type. The chief objection is that when the converter is tilted in operation, the tuyeres are at various levels beneath the molten bath, whereas in the horizontal type they are always at the same level.

Charging Silicious Ore.—In using the Garr gun for charging silicious material to the Pierce-Smith converter, much attention has to be given by the operator. At the Cerro de Pasco plant roller feeders are used for feeding the ore from overhead bins down to narrow tapering hoppers

[1] *Eng. Min. Jour.*, **113**, 113 (1922).

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that deliver in front of the air-jet from the Garr gun. The ore supply is regulated by starting the roller feeder, admitting air to the gun, and thus supplying ore in desired quantity to the converter.

Blowing Equipment.—Turbo-compressors have been used in converter practice, but do not compare in economy with reciprocating steam-driven blowing-engines. This is particularly so when running on a partial load, when the economy of the turbo-generator falls off rapidly, while the reciprocating engine remains nearly constant through a wide range in the amount of air delivered.

Converter-slag Additions to the Reverberatory.—At Tooele, Utah, basic converter slag, previously granulated, when added to the reverberatory charge is an effective flux, which is not the case when poured in, in molten condition. The same practice is to be adopted at Cerro de Pasco.

Moulding Blister Copper.—Blister copper for shipment has generally been cast from a tilting furnace; but, where anodes are not to be made, it is considered cheaper to mould direct from the converter-ladle into casting machines of large capacity. This gives a good product for shipment.

Casting and Handling Matte.[1]—In a paper describing the disposal of matte, Frank Taylor gives the practice at Copper Cliff, Ontario. In the matte-shed there are two groups, each of seven pans, trays or moulds. Each mould is 36 ft. long, 6 ft. wide, and 4 in. deep, and when full holds 7 tons of matte. Each is divided transversely into five sections, these being bolted together and having joints flanged inside. The flanges have an 18-in. gap at the middle, which creates a line of weakness across the sheet of matte, and so, when solidified, it can be broken into five parts. The joints are made tight by retort cement. Before pouring, a cast-iron anchor or lifting block with a hole in its tail where a hook can take hold is set at the middle of each section, and so, when the matte has been poured and becomes solid, each section is ready to lift from the mould. To do this a trolley crane is arranged over each group of pans, being a 10-in. I-beam hung to 4-ton trolleys. From the I-beam is suspended an air-lift having a cylinder 12 in. in diameter with a 6-ft. lift, able to raise four or five tons with an 80 or 90-lb. air-pressure from a hose. This hose is carried on a cable running parallel to the crane-track beams. The crane has an electrically operated double-drum hoist with a ¼-in. hand-cable attached, that returns around a pulley at each end of the shed. The hoist, placed between the two groups of moulds, is at the level of the crane beam, both of them operated from this point. The crane comes along, the air-lift is hooked into the anchor of this 6 by 6-ft. slab of matte of 1½ tons weight, and is picked up and transferred to the loading stations, one at each end of the shed. These loading stations consist each of a

[1] *Min. Sci. Press*, **122**, 790 (1921); *Bull. Can. Inst. Min. Met.*, Nov., 1921.

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set of grizzlies placed at the floor-level and built of 80-lb. rails set into cast-iron chairs. The matte is broken through the grizzlies, falling into a loading pocket. Beneath the pocket is a side-dump steel car of 2½ tons capacity. When the car has been filled it is drawn up an inclined track by means of an electrically operated hoist to deliver its load into a standard box-car for shipment. The hoist is controlled at a point near the loading point, so that the operator can oversee the operation of the small car.

Converter Plant for the Compagnie du Boleo.[1]—This works at Santa Rosalia, Lower California, intends putting in a converter plant so that it can treat its own matte instead of shipping it, as at present, to Tacoma, Wash. The equipment is to be purchased in the United States. The blister copper thus produced will then be shipped by way of the Panama Canal to New Orleans, thence by rail to New York.

Converter Design.—The Allis-Chalmers Co., Milwaukee, Wis., is now manufacturing a Pierce-Smith horizontal converter 12 ft. in diameter by 20 ft. long, electrically driven, and having 30 tuyeres; five of these converters have been furnished for the Cerro de Pasco Copper Corporation in Peru. Four pairs of rollers, which take the weight of the converter, are mounted on equalizing levers. The electric drive has its worm-wheel meshing into a worm, this being carried by a shaft the other end of which takes the main driving pinion, and this in turn engages the converter spur-wheel.

Repairing Ladle Spouts.[2]—E. J. Harris describes the method adopted at the Garfield smelter, Garfield, Utah, for the repair of the large cast-steel matte-ladles there used in the converter department. Due to the hammering on the spouts of these ladles in removing the shells they were well-nigh destroyed. The repair was made by using thermit welding, as follows: The old spout was cut and a new cast-steel one bolted on in the exact position needed, with suitable clearance for making the joint. The joint was filled with wax and the shape of the weld made upon the ladle exactly as this weld was to be cast. The ladle was placed, spout downward, on its side and a brick and ganister mould made both below and above the joint. The wax was now melted out, leaving a cavity of the exact form of the weld, the joint was brought to a red heat, using a gasoline preheating torch, and the joint was poured with molten thermit. Patches have been put in in the same way. The welds successfully withstand the hammering. The matte-ladles weigh 13,182 lb. each, and cost $1,318.20; the new cast-steel spouts weigh 823 lb. and cost $83.20 each. Material and labor on the alteration cost $355.37, so that a saving of $962.83 per ladle was made.

[1] *Eng. Min. Jour.*, 112, 225 (1921).

[2] *Eng. Min. Jour.*, 111, 870 (1921).

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Converting High-grade Matte Containing Metallic Copper.[1]—Referring to the discussion as to the treatment of such matte, M. S. Mazawy relates that he was able to convert a matte of 60-per cent. copper in a Pierce-Smith type of basic-lined converter at an altitude of 7000 ft. above sea-level, using a 14-lb. blast-pressure. But he was unsuccessful in converting a 65-per cent. matte at this pressure, as a converter slag that could be skimmed could not be "raised." For success he considers that a silicious flux of 85-per cent. silica should be employed. It is to be noted that the 65-per cent. matte contained 3.5 per cent. metallics. M. H. Merriss stated that several times in his experience he had treated matte of 65 per cent. in small basic-lined converters when mixed with as much as 25 to 45 per cent. of its own weight of molten metallic copper, and the converting had been successfully carried out without preheating or the addition of fuel. Selective converting was first developed in France by Paul David, who devised a spherical converter with a pocket at the side into which the bottoms of the first portion of the blister copper containing impurities was concentrated, as has been described in MINERAL INDUSTRY. C. A. Grabill, as superintendent at the Shannon Copper Co., relates that when there was a shortage of sulphur in the charge, the matte would run from 55 to 77 per cent. in copper, with an average some months of 65 per cent. Under these conditions a little black copper would also be made, and this tended to accumulate in the crucible, as well as buttons in the matte-pots. When converters were installed this black copper went directly to them, and with the matte was successfully converted to blister copper.[2]

COPPER REFINING

Refinery Production, Selling Agencies and Brands of Copper in the United States.[3]—In 1920 Guggenheim Bros., representing the Hayden-Stone-Jackling interests, were the largest sellers of copper, marketing upwards of 500,000,000 lb. Second comes the United Metals Selling Co. with 350,000,000 lb.; third the Phelps-Dodge Corporation with 200,000,000 lb.; fourth the American Metals Co., an outlet for 150,000,000 lb.; and fifth the Calumet and Hecla Co., with about 100,000,000 lb. to market.

The brands of copper often indicate the name of the producing company and also the grade. There are three grades to consider, *viz.*, lake, electrolytic and casting.[4]

[1] *Eng. Min. Jour.*, Jan. 29, May 26, Apr. 30, and Aug. 6, 1921.

[2] The writer when smelting for black copper at Santa Rita, N. M., about 1900, found more or less of a coating of white metal on occasional black-copper ingots, due to the presence of a little sulphur in the charge. This did not interfere at all with the smelting of the black copper. The slags were high in copper (2.5 per cent.), but that was to be expected. L. S. A.

[3] *Eng. Min. Jour.*, 111, 847 (1921).

[4] Electrolytic copper varies but little in purity. The product of a refinery is generally a mixture of copper from various sources and is frequently changing. The purest copper is taken for the making of wirebars to ensure the highest conductivity.

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Rabbling and Poling Copper at the Raritan Copper Works.[1]—As practiced at this works, the method of blowing copper, equivalent to that of rabbling a refining furnace in the preparation of merchant shapes, consists in the use of ½-in. steel pipes for blowing air into the bath of molten copper under pressure of about 45 lb. per sq. in. for the purpose of oxidizing the bath to eliminate impurities. The steel pipes 10 ft. long, two to each furnace side door, are connected by ½-in. hose to the main air-supply pipe running along above in front of the furnace. The other ends of the blow-pipes, resting on the door-sills, are bent so that they dip 8 in. beneath the surface of the bath. As the pipe softens and burns away it is withdrawn, the end bent anew and again inserted, and so on till the pipe gets too short and has to be replaced. Blowing generally lasts 6 or 7 hr., test samples being taken from time to time until the copper is at the pitch of set copper, containing 4 to 6 per cent. of cuprous oxide. Poling then follows, using green young beech or oak trees, as pine is objectionable. With the high cost for wood it seems likely that oil or gas may be substituted, or possibly pulverized coal injected with the aid of steam pressure.

While refining furnaces are commonly hand-fired with coal, mechanical stokers have been successfully employed, and at one refinery powdered-coal firing was installed in 1919, while the Raritan works is now using oil with much success.

"Copper Refining," by Lawrence Addicks, 206 pp., 6 × 9 in. illustrated, McGraw-Hill Book Co., New York, was published in 1921. The separate chapters of this work appeared during 1916 and 1917, in *Chemical and Metallurgical Engineering*, and abstracts from them are contained in MINERAL INDUSTRY, **26**, 192, **28**, 211 and **29**, 204. This book is written by a metallurgical engineer of high standing who gives the results of his extensive experience in electrolytic copper refining, an art for many years pursued under conditions of great secrecy. The contents are as follows:

Metal losses; Metals in process; Tank resistance; Current density; Current efficiency; Impurities; By-products; Furnace refining; Requirements of refined copper; Copper from secondary material; Power problem; Elements of design; Application to other fields; Index.

COPPER AND ITS ALLOYS

Tempered Electrolytic Copper.[2]—Elastic or tempered copper can be produced by deposition from a copper-sulphate solution on a cathode rotating at a peripheral speed of 1000 ft. per min. The hardness of the coating is increased at higher speeds, or by the addition of say 0.1 per

[1] *Eng. Min. Jour.*, **111**, 793 (1921).
[2] *Chem. Met. Eng.*, **24**, 795 (1921); British Pat. No. 154,373, Jan. 26, 1921.

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cent. of glue or gelatine, or by arsenic, preferably to the amount of 0.07 per cent. of the standard electrolyte. The arsenic may be added in the form of an oxide dissolved in a 10-per cent. caustic-soda solution.

Physical Properties of Copper-bearing Iron or Steel.[1]—Addition of copper in small amounts to iron or steel makes them rust-resistant in greater degree. Because of such additions the physical properties are modified as follows:

Red-shortness over a certain range of temperature results, the range increasing with increasing copper. This condition is thought to be due to an intergranular film of copper or copper alloy. The red-shortness is removed by addition of manganese or chromium in sufficient quantity. This is why in steel copper does not so act, *i.e.*, the manganese present overcomes the red-shortness. Addition of copper up to 3.5 per cent. does not seem to impair cold-working. Beyond 2 per cent. Mn, or of Cr, also present, the alloy becomes too brittle to work.

Latent Heat of Fusion of Monel Metal.[2]—Walter P. White has recently carefully redetermined the latent heat of fusion of Monel metal, the natural copper-nickel alloy. He finds it to be 68 calories per gram at the just-melting temperature of 1260° C. For nickel the latent heat is 73 calories at its melting point of 1460° C., while for copper it is only 43.3 calories at its melting point of 1083° C.

Heat-treatment of Copper Alloys.[3]—An alloy of 70 to 80 per cent. C alloyed with 10 to 15 per cent. Mn and 10 to 15 per cent. Al, when rolled, annealed, and cooled, had an ultimate tensile strength of 93,720 lb. per sq. in., and an extension of 21 per cent. When subjected to an annealing temperature of 220° C. for 20 hr., this strength had increased to 136,320 lb., but with a 10-per cent. extension only. The hardening thus given rendered the metal suited to the manufacture of knives. A marked hardening takes place in the case of a brass alloy of 51 per cent. Cu, 40 per cent. Zn, and 9 per cent. Mn, for after rolling at high temperature, forging and annealing at 600° C., and cooling, a tensile strength of 76,680 lb. was attained with extension 11 per cent., and a Brinell hardness of 166. After heating for 36 hr. at 230° C., the same alloy had acquired a strength of 85,200 lb., with but 2 per cent. extension, and a Brinell hardness of 260. Alloys containing manganese, silicon, and copper, hardened in this manner at temperatures of 200° to 400° C., may be used in place of tin alloys for bearing-liners.

Copper-cadmium Wire for Electrical Transmission.[4]—W. C. Smith, metallurgist, U. S. Metals Refining Co., Chrome, N. J., gives the advantages of this alloy as compared with electrolytic copper. Good

[1] *Chem. Met. Eng.*, **24**, 565 (1921).
[2] *Chem. Met. Eng.*, **25**, 17 (1921).
[3] British Pat. No. 161,537, May 25, 1921; *Chem. Met. Eng.*, **25**, 33 (1921).
[4] *Chem. Met. Eng.*, **25**, 1179 (1921); U. S. Pat. No. 1,307,642, June 24, 1919.

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annealed copper wire should have a conductivity of 98.5 Matthiessen standard. Hard-drawn copper wire, 0.46 in. diameter, has a tensile strength of over 49,000 lb., and when of 0.04 in. diameter, of 67,000 lb. per sq. in. Such copper can be annealed, and so softened, by being heated to 175° C. for 72 hr., or in a few seconds when brought to a temperature of 310° C. The tensile strength of copper wire limits the distance between supports; accordingly, the low annealing point of hard-drawn copper wire is against its use where, either by intention or accident, the temperature may rise high; also, soft, heavy copper wire is often subject to severe abrasion in use. A copper-cadmium alloy of 1.1 per cent. Cd has satisfactorily fulfilled severe requirements. As compared with copper it has greater tensile strength, is harder, and has a higher annealing temperature, while conductivity falls off less. Now the melting point of copper is 1083° C., and cadmium melts at 321°, with a boiling temperature of 778° C. It was therefore found best to prepare a copper-cadmium alloy of 50 per cent. cadmium, since such an alloy can be produced by careful addition of solid cadmium to the molten copper with but little loss, which can then be added in right proportion to form the desired alloy. The copper is melted in a large ladle and the calculated amount of the base (50-per cent.) alloy added to produce that of 1.1 per cent. The metal is then poured into wirebar moulds. The wirebars were drawn into 0.081-in. wire and tested with uniform results. The 1.1-per cent. copper-cadmium alloy had a tensile strength of 100,000 lb. per sq. in., and a conductivity of 91.0 Matthiessen standard. This alloy has been successfully used for wireless aërials, long-span transmission wire, and for trolley wire.

Effects of Heat-treatment upon Brass and Brasses Carrying a Little Tin.[1]—We herewith present the results of an investigation by Leon Guillet. The table gives the characteristics of a brass of Cu, 60.15; Zn, 39.84; Sn, 0.00, Fe and Pb, traces.

MECHANICAL PROPERTIES OF 60 : 40 BRASS

	Tension Tests.				Impact Tests.		
	Ultimate Strength.	Elastic Limit.	Elongation.	Contraction.	Resilience.	Angle, Degrees.	Hardness.
Rolled	54,000	17,100	48.0	51.7	14.3	.....	93
Annealed at 800° C	52,000	14,600	50.0	62.2	17.5	110	78
Quenched at 600° C. in water	51,500	?	36.0	52.7	13.3	139	92
Quenched at 800° C. in water	53,000	33,100	8.0	11.5	7.8	153	145

This shows that for such brass quenching at 800° C., though not affecting tensile strength, cuts down greatly the elongation, contraction and resilience, but a hardness of 93 in the rolled specimen was increased to 143, Brinell standard, in the quenched sample. As respects the tin brasses,

[1] *Revue de Métallurgie*, July, 1921, pp. 445–458; *Chem. Met. Eng.*, **25**, 1009 (1921).

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having 60 per cent. Cu, but with varying amounts of tin up to 5 per cent., the following general conclusions are striking:

In rolled and annealed samples, tin increases the ultimate strength slightly up to 0.8 per cent. Sn, affects the elastic limit but slightly, reduces elongation, reduction of area, and resilience, and increases hardness a little. Quenching the rolled bars from 800° C. greatly increases the hardness, but gives bad results as to ductility and resilience. Quenching at 600° C. of a brass containing at least 1.0 per cent. tin increases ultimate strength from 50,000 to 64,000 lb., the elastic limit from 17,000 to 28,400 lb. per sq. in., the reduction of area from 40 to 60, the resilience from 12 to 16, and the hardness from 95 to 105 Brinell. But with an alloy containing Cu 67.61 per cent. and Sn 1.53 per cent., but little change was observable, due to the greater percentage of copper. These investigations indicate (1) that tin in quantity less than 1.0 per cent. is not so injurious to the brass as generally thought; (2) that quenching suppresses a hard and brittle constituent, and considerably improves the mechanical quality; (3) that brasses of Cu 60.0 per cent. and Sn 1.0 to 2.0 per cent. are less notable in the drawn or rolled state, aside from their known non-corrosive property, but are improved by quenching.

Physical Qualities of Aluminium Bronze.[1]—A review given by A. A. Blue discusses the shortcomings of this copper-aluminium alloy, which contains Cu 90 per cent., Al 10 per cent., and occasionally 1 per cent. iron, replacing copper. One of the prominent engineering books gives 100,000 lb. as the tensile strength of forged aluminium bronze. Tests of bars thus tested gave a strength close to 80,000 lb. Such bars, when reheated to 900° C., quenched in brine, and drawn at 540° C. showed a tensile strength as high as 86,000 lb. and an elastic limit of 44,800 lb. per sq. in., but the factors of elongation and contraction were greatly diminished, that is, brittleness had increased. Another example was for the *cast* metal quenched at 870° C., whose ultimate strength was 66,500 lb., its elongation 15.5, and reduction in area 18 per cent. The Brinell hardness was 192. In the foundry the alloy has been found difficult to cast, due to the formation of piped and defective pieces. In conclusion it may be stated that (1) heat-treatment produces marked and consistent changes in hardness, but (2) little effect on tensile strength and the yield-point; (3) forging produces little effect on tensile strength; (4) aluminium bronze is very difficult to handle in the foundry, giving uncertain results; and (5) the published figures cannot be confirmed.

Marketing of Mattes, Blister Copper and Copper Ores.[2]—Albert R. Ledoux discusses the conditions under which the above-named copper products are marketed, and their contained metals paid for.

[1] *Chem. Met. Eng.*, **25**, 1043 (1921).

[2] *Eng. Min. Jour.*, **113**, 142 (1922).

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Mattes.—There are a few copper mines whose ores are smelted to a matte, but whose production is too small to justify their converting it, so that it is sold direct to a refinery or large works. By contract the seller agrees to deliver regularly matte of his customary grade, say from 35 to 55 per cent. in copper. Assays are made by both buyer and seller, and within "splitting limits" the average of the two is taken for settlement. Beyond these limits an umpire is called in. Splitting limits are for copper 0.25 per cent., for silver 1 oz. and for gold 0.03 oz. per short ton. A deduction of 0.5 per cent. is made for moisture. From the copper contents is deducted 1.3 per cent. for an assumed loss in smelting, also a smelting and refining charge of 2.9 cts. per lb. of copper. If money is advanced by the buyer against a bill of lading, this is of course deducted from the amount due, but interest is charged upon such advances until the settlement is made. Hence, we have for example:

SETTLEMENT FOR IMPORTED COPPER MATTE

	Buyer's Assays.	Seller's Assays.	Settlement.
Copper, per cent	47.45	47.43	47.44
Silver, ounces	0.53	0.59	0.56
Gold, ounces	0.10	0.10	0.10
Moisture		0.50 per cent.	
		Pounds.	
Net weight of lot		100,000	
Less moisture at 0.50 per cent		500	
Dry weight		99,500	
Copper assay—47.44 per cent. less 1.30 = 46.14 per cent. of 99,500 lb. = 45,909 lb.			
45,909 lb. of copper at 13 cts		$5,968.17	
Less smelting and refining charge at 2.90 cts. per lb. of copper		1,331.36	
Value of copper			$4,636.81
95 per cent. of silver content at 66¼ cts. per oz			17.54
Gold content at $20 per oz			99.50
			$4,753.85
Less advances			4,000.00
Net			$753.85

Blister Copper.—The settlement terms are similar to the above, except that in place of the 1.3-per cent. deduction, there is one of 0.25 per cent. or so for refining. Of the copper as found by assay, 99.75 per cent. is paid on the day of settlement. Of the silver 95 per cent. is paid for if less than 50 or 60 oz. per ton, but for all excess beyond that figure there is a further deduction of 5 per cent. The gold is paid for at $20.00 per oz. For refining a charge of $27.50 a ton is made. As in case of the matte, a deduction of 0.5 per cent. is made for moisture, since water is occluded in cavities when the blister is cooled by the hose, and also because of exposure to the weather.

Imported Copper Ores.—From the assay value of the copper the usual deduction of 1.3 per cent. is made, and the remaining copper is paid for at 2 cts. less than the New York quotation. Gold is paid for at $20.00 per oz., silver at 95 per cent. of the New York quotation. The splitting

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limits are for copper 0.2 per cent., for silver 0.8 oz., and for gold 0.05 oz. per ton. For treatment of neutral ores there is a base charge of $2.00 per ton, but an excess of silica is penalized. Excess alumina, zinc, arsenic, antimony, and bismuth are penalized. Concentrates that have to be briquetted have a briquetting charge. The degree of fineness is such that at least 35 per cent. will go through ¼-in. mesh. The date of settlement may be given at 60 days after arrival at the buyer's yard, or of agreement of assays.

Imported ores of 10 per cent. or over in copper, and high in silver, are thus paid for: With a silver content under 6000 oz. per ton 98.5 per cent. is paid, if over 6000 oz. then 99.0 per cent. of the silver is paid for at the New York quotation for foreign silver, while the gold is paid for at $20.50 per oz., all on the tenth day after sampling. As to the copper, a 1.3-per cent. deduction is made from the assay result, and the residue is paid for at 3 cts. less than the New York quotation. Besides this $25.00 per ton is charged for smelting.

Hydrometallurgy of Copper

Several new copper leaching plants are under consideration.[1] At Potrerillos, Chile, plans have been made for a plant according to plans developed at Anaconda.

W. E. Greenawalt has invented a leaching process involving sulphate leaching and electrolytic precipitation. His method prevents the building up of ferric sulphate in the electrolyte; also the copper in the rejected solution is precipitated by means of hydrogen sulphide. The resultant precipitate, while still semi-fluid is pumped back into the system, so that all the copper is produced as electrolytic.

Symons Disc-crusher in Leaching Practice.[2]—A. W. Allen tells of the construction and the merits of this crusher. This disc-crusher is used principally in stage crushing following the ore-breakers. As compared with a breaker of like capacity it takes less head-room, and crushes with greater economy of power. This is because the ore during crushing travels toward an increasing discharge-area, and not to a decreasing one where the just-crushed pieces would undergo further unneeded crushing before discharge. While the range of reduction is less than in the jaw-crusher, or than with rolls, on the other hand less fines is made. The machine is stable during its life, and does not wear irregularly as do rolls, where grooving and corrugation soon set in. The principal difference between the two types is that in the horizontal type the size of the product is controlled by the maximum opening between the discs, and in the vertical shaft machine by the minimum opening. In this latter the ore

[1] *Eng. Min. Jour.*, **113**, 110 (1922); *Min. & Met.*, Oct., 1921, p. 13.
[2] *Min. Sci. Press*, **123**, 849 (1921).

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is fed through the center of the upper disc, and falling upon the lower one, is swept outward by centrifugal force to be crushed between them. The material on the lower plate cannot escape until the discs have come together, and every piece must be reduced to the size of the minimum opening before it can be released. Thus, when crushing to ¼-in. minimum opening, the greatest opening would be ¾ in. These machines are 48 in. in diameter of the discs, and the upper disc can be arranged to permit coarse crushing. The feed in such case may be 4½ in. in size and a product can be yielded of ½ in., or again, by altering the adjustment, it is possible from a 2¼-in. feed to obtain ⅛-in. size. These standard machines take about 50 hp.

Both the Ajo and the Chuquicamata plants have adopted the machine for the final reduction, and it is recognized that dry crushing is superior to wet. When water is used in crushing, segregation occurs whereby the slimes get separated from the coarse, so that one part of a charge is open, another tight, resulting in channeling and uneven leaching.

Copper Leaching Practice.[1]—Frank E. Lathe discusses the practice at six representative American plants. At four plants, the Anaconda, Chile Exploration (Chuquicamata), New Cornelia (Ajo), and Utah Copper, sulphuric acid is the solvent. At Anaconda sand tailings are roasted to bring the copper into soluble form, but at the other three, crushing of the ore to minus ½-in. mesh is sufficient. To recover the copper from its solution the Anaconda and Utah Copper use scrap iron, while at Chuquicamata and Ajo electrolytic precipitation prevails. One should add that at Ajo, as the electrolyte gets foul, part of it is by-passed and passed over scrap iron. At two plants, Calumet & Hecla and at Kennecott, ammonia leaching is used, Calumet & Hecla employing ammonium carbonate, Kennecott, ammonium hydrate. In these two cases heating the solution to boiling effects precipitation.

Crushing of run-of-mine ore must be fine enough to ensure speedy and complete extraction in reasonable time. Finer crushing than to fulfill this requirement costs more, makes much dust, and hinders percolation, with tendency to channeling and more difficult washing. For grinding, Symons disc-crushers are much used, supplemented in some cases by rolls. With such grinding to minus ½-in. size, leaching can directly follow without the necessity of de-sliming the product. Where sulphide ore is to be leached, a preliminary roast is given to bring the copper into water-soluble condition, and the gangue into insoluble form, agglomerating the finer particles. The heat of roasting may volatilize some impurities. Free access of air is needed in roasting these sulphides, and temperatures must be carefully controlled. Where the ore carries

[1] *Bull. Can. Min. Inst.*, June, 1921; *Eng. Min. Jour.*, Mar. 12, Apr. 16, and May 14, 1921.

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silver, salt has been used, as at Anaconda, but it has been discontinued there on account of the expense.

As a solvent, sulphuric acid is preferred because it can be made locally from waste acid gases, and so is cheap, is easily regenerated by electrolysis, makes copper of high purity, and is easily handled. The objections to its use are that it does not dissolve native copper, dissolves but half the copper in cuprite, attacks carbonates in the gangue, and has some action on metal containers. Ammonia leaching has its advantages that it is free from the just-named drawbacks, and that the ammonia can be perfectly recovered by distillation. On the other hand the solvent is expensive, and has not thus far been regenerated by electrolysis, is volatile, and the copper precipitate yielded is impure. Ferric salts are good solvents for native copper, or for copper in oxidized ores, and do not attack the gangue, but in their presence precipitation of the copper by electrolysis is impossible. These salts, when reduced, are also hard to oxidize. Sulphurous acid has encouraging possibilities. Ore, crushed to minus ½-in. size, must be carefully charged to the leaching tanks, usually to the depth of 10 to 15 ft., and may be filled by conveyor-belt. The cycle of leaching operations varies a good deal. At Chuquicamata, leaching is upward for the first solution, then downward; at Ajo it is altogether upward. Upward percolation extracts the copper more rapidly, and there is less channeling, but extraction is not so complete. Downward percolation results in a better clarified solution, and needs less power to perform it. Continuous percolation is more necessary on high than on low-grade ore. Extraction should be at least 85 per cent. The leaching tanks are usually made of reinforced concrete with a lead lining, or one of mastic asphalt. A protective lining of wood is also provided to take the wear in charging and discharging. Small tanks are often of wood with a lining of sheet-lead. In scrap-iron precipitation the acid in the solution is wasted, so, when this time comes, the acid should be low; also a low acid means a low scrap-iron consumption. This at Anaconda is about 60 lb. of 60° B. acid per ton of the tailings. At Ajo, where the gangue is more soluble, it is 90 lb., while at Chuquicamata, where sulphuric acid exists in the ore, only 4 to 5 lb. is needed. Whether to precipitate by electrolysis or by scrap iron depends on the respective costs. Ferric iron must be reduced to ferrous form before the copper-bearing solution goes to the electrolytic tanks, and at Ajo this is done by treating the solution with SO_2 gas. At Chuquicamata chlorides in the solution cause trouble, and are precipitated as cuprous chloride by agitation with cement copper, this also reducing any ferric iron present. Chlorine, up to 0.05 per cent., and nitric acid (also existent), interfere but little with current efficiency if the ferric iron is low

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and the electrolyte not warm. The solution is accordingly cooled artificially.

Anodes for electrolytic precipitation have been made of graphite, antimonial lead, ferrosilicon, and fused magnetite. Graphite can be used at low voltage, and effectively regenerates the sulphuric acid of the electrolyte, but the liberated oxygen, as also ferric salts, corrode it. However it merits further trial.[1] Lead anodes are not satisfactory in presence of chlorine or nitric acid, so fused magnetite was chosen just previous to the great war; but the supply from Germany having been cut off, ferrosilicon, better in mechanical and electrical qualities, but inferior chemically, was substituted. At Ajo, on the other hand, lead anodes have been a great success.

When electrolysis is used, current efficiency is usually low until the workmen acquire experience. With trained men it should be 85 per cent., and the copper deposited per kilowatt-hour should be 1.1 lb. At Ajo, with a current resistance of 2 volts, amperage becomes 7.5; in Chile, with anodes of greater resistivity and nearly double the current density, it is about 2.8 amp. per sq. ft. Scrap-iron precipitation is rather adapted to small plants. Old tin cans and other iron scrap, as well as sponge-iron, have been employed. Nearly 2 lb. of scrap is needed per pound of copper, and the resultant precipitate or cement copper will carry 30 to 35 per cent. of impurities. Modified tube-mills seem to be superior to tanks for precipitation.

In ammonia leaching, steel tanks can be used, and no fouling of the solution occurs. At the Calumet & Hecla plant there is a loss of 1 lb. of ammonia, and at Kennecott 0.5 lb. per ton of solution, both using an elaborate system of steam-washing. The copper recovery reaches 80 per cent. The most promising extension of copper leaching would seem to be in the treatment of large bodies of partially oxidized ores, where the copper is readily soluble in sulphuric acid or ammonia, while the gangue is not.

Reactions in Heap-leaching.[2]—G. D. Van Arsdale disagrees with the conventional explanation of the chemical reactions in heap-leaching at Rio Tinto, and believes further investigation may show that the process proceeds as follows: Oxidation of the pyrite begins slowly at ordinary temperatures, but rises as heat increases, the moisture present acting as a catalyst. The reaction, being exothermic, causes rapid heating-up, especially in confined spaces where the heat hangs.[3] Then, to hold this

[1] G. D. Van Arsdale adds that lead anodes are also attacked, but such attack in either case is only true for solutions of pure copper sulphate. In presence of depolarising agents such as SO_2 or ferrous sulphate, however, disintegration need not result with respect to graphite, nor need we fear peroxidation in the case of the lead anode.

[2] *Min. Sci. Press*, **122**, 122, 451 (1921); MINERAL INDUSTRY, **29**, 215 (1920).

[3] Settlement of the newly built pile, under the static head of 20 ft. or more, must cause local compression and heating to start this exothermic reaction, which readily spreads until stopped by cutting off the draft. L. S. A.

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down, the air must be largely or wholly shut off to prevent spontaneous ignition. So it is that the minute amounts of SO_2 are no doubt oxidized in the presence of moisture and extended contact surfaces to SO_3, ready, in intimate presence of any iron oxide, to form ferrous or ferric sulphate. The conversion of copper sulphate is explained in the same way, especially that which, as at Rio Tinto, is susceptible to such change. As to the condition of lumps of pyrite ore, capillary action is conceived of as due to the iron-sulphate solutions penetrating the lump and dissolving the pyrite; then when the lump dries the same action brings the copper, also dissolved, to the surface.

Operations of the Chile Exploration Co. at Chuquicamata.[1]—Many interesting details of operations as they have here developed are given by A. W. Allen. In the weathered zone, in addition to the principal ores, *viz.*, brochantite ($CuSO_4.3Cu(OH)_2$), atacamite ($Cu_2Cl.H_2O_2$) and chalcanthite ($CuSO_4.5H_2O$), there are a number of rarer minerals, also sulphates. In the sulphide zone the principal copper minerals are pyrite ($CuFeS_2$), enargite ($3Cu_2S.As_2S_7$), together with chalcocite (Cu_2S) and covellite (CuS). The oxidized merges into the sulphide zone, so that the mixed zone is of considerable extent, the ore reserves amounting to 150,000,000 tons, and carrying nearly 3 per cent. copper. This mixed ore is not now to be treated, since there are immense reserves of easily-soluble copper minerals. The water-level is usually in the mixed ore zone, sometimes in the oxidized zone. A steady decrease of oxidized ore is found in depths, chalcocite being first met with, then a mixture of this with primary sulphide, then primary sulphide only.

Ore, mined by steam-shovel, is transported to the mill in large cars of 68 tons capacity. The cars at the crusher station enter a special tipple that locks the car, elevates it 30 ft., turns it over, and discharges the contents upon grizzlies which precede two 84 by 60-in. jaw-crushers, each crusher having a capacity of 1200 tons per hr. and breaking to 10-in. size. To allay the dust the ore is sparingly sprayed with a hose. The crushed ore, joined by the undersize of the grizzlies, drops upon a 48-in. conveying belt, and by means of a shuttle conveyor, is distributed throughout a primary ore-bin of 13,000 tons capacity. The crushed ore is drawn from the ore-bin by means of 16 pan-feeders delivering to three 36-in. belt-conveyors. Each belt-conveyor discharges over a grizzly, the oversize of which goes to a McCully crusher, where it is reduced from 10 in. to 3 in. The crushed and screened ore is delivered to three 36-in. belt-conveyors, over which three stationary mushroom magnets are hung, for the removal of tramp iron and steel. The ore again passes over a grizzly, after which it is fed to eight 48-in. horizontal-disc Symons

[1] *Min. Sci. Press*, **122**, 835 (1921); MINERAL INDUSTRY, **23**, 259 (1914); **24**, 249 (1915); **25**, 261 (1916); **29** 223 (1920); Report of the Chile Copper Co. for 1920.

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crushers, which reduce it to 1½ in. The final crushing is done in twenty-four 48-in. vertical-disc Symons crushers, the leaching product containing about 13.5 per cent. of material that will rest on a 0.371-in. screen.

This method of stage-crushing results in a minimum production of fines, even when crushed to minus 0.371 in., and so to better leaching. In this crushing, dust is necessarily made, causing serious discomfort, even when masks are worn. This is due to the acridity of the ore particles on the mucous membrane of the nose and mouth, especially in the crushing of such great tonnages of ore. This nuisance is reduced as much as possible by boxing in the secondary crushers. Symons disc-crushers are now used in place of high-speed rolls.

An elaborate system of cross-conveyors takes the ore to the leaching vats, three Vezin machines being used to cut out the final sample of 400 lb. from each vat-charge of 10,000 tons or so. The main conveyor, 36 in. wide, runs along beside the length of the leaching vat, and rises 12 ft. to its tripper, to deliver upon the 36-in. vat-filling belt. This belt delivers by means of its tripper continuously and evenly across the vat, and takes 12 to 14 hr. to fill it. A Merrick weightometer is interposed in the conveyor to determine the weight of the charge.

The construction of the vats is described in MINERAL INDUSTRY, **23,** 259 (1914). Six of the original vats were 150 ft. long, 110 ft. wide, and 16 ft. deep, and this depth has been increased to 17½ ft., so they now hold well over 10,000 tons. Three newer vats of the same area have a depth of 19 ft. 6 in. One notes that the cocoa-matting filter-cloth is laid without particular care, and is not calked at the edges. Owing to the loose and even filling of the vats there is but little resistance to the flow of solution, and no short circuiting due to the presence of slimes. One should here note that the true slime present in the ore is small. Screen analysis shows but 4 per cent. of minus 200 mesh, and 6 per cent. of minus 150 mesh. The actual area of percolation is not more than 11 per cent. of the vat bottom, so one can see that leaching is easily carried out. The cocoa-matting which lies beneath the shoveling slats, where covered by them, has but little use, and rots there to be replaced about every five years. The cost of such replacement is negligible as figured to the tonnage treated. It has been suggested that when the time comes to renew the false bottom a sand bed could be substituted, as being cheaper and more permanent. Such a bed, beginning with sized gravel below, should be progressively finer upwards, and should be protected, as the cocoa-matting now is, by the shoveling slats. The term filter-bottom is conceived as being a misnomer, since its function is to support the charge, preventing any movement of solids in the direction of flow, and the cocoa-matting or the sand-bottom does not act as a "filter." As-

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suming correct operation, the solutions, whether by downward or upward percolation, should be clear, and certainly in the latter case filtration through a medium other than the ore itself has not occurred.

Each leaching vat has eight 6-in. drain-pipes, calked at the bottom with hard lead, and converging to the main drain that goes to the pump-house. In place of lead-lined iron pipe at first used, pipe made of mastic or tarred-wood pipe is now preferred. Leaching is done by downward percolation, after, of course, upward submergence of the charge as it is filled into the vat. The rate of downward flow, measured above the surface of the charge, is 24 in. per hr. The flow from the vat is intermittent, so that there is some soaking, but it is such as will satisfy the needs of the electrolytic department. There seems to be no advantage in circulating the solution in an individual tank, since this returns the pregnant solution upon the ore, and part of this is so left throughout the charge in place of being drained away. Treatment solutions consist of spent electrolyte from the tank-house and a portion of the wash-solution, which is moved forward. The acidity is kept constant at 5.5 per cent. by addition of sulphuric acid if necessary. During 1920 2.64 lb. of acid was used per ton of ore; at present none is needed. The treatment solution passes through a partly leached charge, then goes to a fresh one, acting upon it from 4 to 24 hr. The first effluent from this will carry 4.6 per cent. Cu, then goes to the dechloridizing plant. The time of treatment is four days, the last day being for a water-wash and for drainage. The water so used is but 0.15 ton per ton of ore, and the last drainage carries 0.14 per cent. Cu. The exhausted tailings carry about 8 per cent. moisture. Of the first effluent from the vats some 15 per cent. is by-passed for thorough precipitation of its copper, and is then run to waste. This is due to the gradual fouling of the solution. The impurities thus accumulated are alkaline sulphates and nitrates derived from the near-by soil. To replace water-loss thus made, as well as that in the tailings, by evaporation and by leakage, additions of fresh water, used for washing, are made. A typical charge of 11,000 tons (Sept. 21, 1920) contained 0.06 per cent. Cl, with copper 1.71 per cent., and in the tailings 0.112 per cent., indicating an extraction of 93.4 per cent.[1]

The residue from the leaching process at Chuquicamata is removed from the vats by electrically operated grab-buckets of the clam-shell type. These are of 6-ton capacity in the two bridges that span six of the leaching tanks, and of 12-ton capacity in the new bridge that unloads the three leaching tanks which were recently constructed. These grab-buckets deliver the material to hoppers that lead to side-discharging cars, in

[1] The report of the company for 1920 states that 4,243,301 tons was crushed and 414 charges leached, the average extraction of the copper being 91.9 per cent. as compared with 88.5 per cent. for the previous year.

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which the residue is hauled to the dump by locomotives. A residue sample is taken automatically by means of Vezin machines that are adjusted to cut a proportion of the flow of material to the dump-cars.

The solutions from the leaching process are handled by centrifugal pumps lined with antimonial lead. Eight of them are 15-in., driven by 200-hp. motors, and four are 9-in., two driven by 75-hp., two by 50-hp. motors.

All the strong solution from the leaching-vats goes to the dechloridizing plant, where the chlorine in the solution, usually amounting to about 3 gm. per liter, is precipitated by means of cement copper in agitators of a special type. The resultant cuprous chloride is allowed to settle, the decanted solution (from which about 80 per cent. of the chlorine has been removed) going to the electrolytic department. The cuprous-chloride sludge is removed from the settlers by grab-bucket, and is dissolved in ferrous chloride, the resultant solution being passed through cylindrical mills that are filled with scrap iron. The cement copper produced goes to settling-vats; the overflowing ferrous-chloride solution from these is used to dissolve more cuprous chloride and is returned to the precipitating-cylinders. The cement-copper sludge is removed from the settling-vats by grab-bucket mechanism, and is returned to the dechloridizing agitators. The cement copper, therefore, remains in the circuit, being used in the first place to precipitate cuprous chloride, and later being reformed by precipitation with iron. About 20 per cent. of the cement copper is removed from operation each cycle and sent to the melting-furnace to be cast into soluble anodes for the electrolytic-cell house.

After passing through the dechloridizing plant the solution is pumped to the main solution head tank. This is 90 ft. long, 60 ft. broad, and 12 ft. deep, and is constructed of reinforced concrete lined with mastic. From here the solution passes to the depositing cells, of which there are now 894; these are 19 ft. long, 3 ft. 6 in. broad, and 4 ft. 10 in. deep. Each cell has 44 ferrosilicon anodes with five bars to the anode, each bar measuring 48 by 4½ by 1 in. The cathodes measure 3 by 4 ft., and there are 45 per cell. The current density used for copper deposition when operating at full capacity is 11.4 amp. per sq. ft. of cathode surface.

The starting-sheets are made in 64 cells, of the same dimensions as those in the "commercial" cells, the current-density used being 18 amp. per sq. ft. of cathode surface. The soluble anodes that are used in making the starting-sheets are allowed to be eaten away until about 20 per cent. of the copper remains. They are then replaced with new anodes; the scrap is sent to the anode-furnace for re-melting. The cells used for de-copperizing the wasted solutions are 46 in number, and are of the same dimensions as the others. The commercial copper sheets,

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or cathodes, formed in the cells weigh about 150 lb. apiece, and take about 10 days to form. They are transported to the melting-furnace by means of a light railroad. The copper used for the production of the soluble anodes is melted in a 100-ton oil-fired reverberatory furnace, which has a hearth dimension of 26 ft. 3 in. by 11 ft. 6 in. The metal runs to a tilting ladle, and from there to a casting-machine, the final plate being 4 ft. by 2 ft. 11 in. by ¼ in.

There are three oil-fired reverberatory furnaces used for melting the cathodes and casting them into marketable shapes. Two of these furnaces have a hearth dimension of 41 ft. by 13 ft. 10 in., and a capacity of about 200 tons per charge. The third furnace has a hearth 50 ft. by 13 ft. 10 in. and of 250 tons capacity per charge. Wirebars of 135 to 275 lb. and ingot-bars of 65-lb. weight are made in an endless-chain casting-machine. It started operations in April, 1920.

Plans for extension of the plant have been made by which an ultimate yearly capacity of 300,000,000 lb. will be attained from the treatment of 35,000 tons of ore daily.

The Chile Copper Co.[1]—This company now controls the Chile Exploration Co., with mine and mill at Chuquicamata, and power plant at Tocopilla, Chile.

Chloridizing and Leaching in Sweden.[2]—M. N. Ostman describes the process of treating pyrites cinder and roasted concentrates, as practiced at the Fredrickstad Copper Works, Helsingford, Sweden, according to the Ramenia system, a modification of the Longmaid-Henderson process.[3]

By the action of the air upon the added pyrite in a hot furnace, SO_2 is formed, and due to mass-action of the furnace charge, not only is the SO_2 oxidized to SO_3, but this reacts upon the common salt to unite with and form copper chloride all according to these reactions:

$$2FeS_2 + 15O = Fe_2O_3 + 4SO_3 \quad (1)$$

$$SO_3 + O + 2NaCl = Na_2SO_4 + Cl_2 \quad (2)$$

It is seen that SO_2 forms first, which, owing to the effect of the furnace mass as a contact substance, is oxidized to sulphuric anhydride. Then follows the setting-free of chlorine to react upon copper sulphate. The above reactions are exothermic, and so maintain the furnace temperatures when the proper ore mixture is fed.

For roasting the Ramen-Beskow five-hearth furnace is used.[4] The furnace is heated by producer gas, made from tarry wood, and applied

[1] Company report for 1920; *Min. Sci. Press*, **123**, 130 (1921).
[2] *Eng. Min. Jour.*, **111**, 417 (1921).
[3] The Ramenia system has been installed in Norway, Sweden, Germany, Austria, Russia and Japan. The Ramen-Beskow furnace resembles the Wedge roasting furnace.
[4] MINERAL INDUSTRY, **27**, 222 (1918).

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at the first or upper floor, the combustion gases passing by a special flue to the stack. The lower hearths are separated from the upper one, so that the strong acid gases there formed in them leave through flues leading to scrubbing towers, where they are condensed by water. The furnace draft is regulated by fans, so as to be under close control. The producer gas is injected by a fan, while another fan feeds in the air that mixes with the gas at the intake. Cast-iron fans between the furnaces and the acid towers, controlled by speed regulators, draw off the acid gases from the lower hearths. The circular hearths are enclosed within brick walls, and the furnace is square, with flues at the corners. Two horsepower is needed to drive the furnace.

The temperature at the first floor reaches 300° C. On the second floor chloridizing sets in, the temperature rising 555° to 600° C., and being self-sustained. At this heat copper chloride does not volatilize nor the ore get caked, so that no barring-out of the hearths is necessary.

Based on pre-war prices and the price of labor in Sweden, the cost for roasting in hand-furnaces was $0.96 as against $0.20 for the multiple-hearth furnace.

The plant at Oscarshamm, Sweden, has been running for about two years, and contains the latest improvements of the Ramenia system. It is situated on the coast, and receives the pyrites cinder by barges. These are unloaded by a traveling crane, having a grab-bucket, into a hopper car, the material going then to the cinder storage-bins that hold several thousand tons. Thence the cinder is transferred to a feed-bin, containing a 24-hr. supply, to the roasters, and in one of the bins the salt is placed. Below the bins are weighing hoppers to regulate the percentage of salt to be added, and to mix the charge. Norwegian pyrites of different grades is used. Before going to the furnaces, the ore, which is soft, is ground in Kent mills to 10-mesh size. The percentage of salt needed varies, so that, with as much as 6 per cent. of zinc present, it may amount to 20 per cent. In cinder mixtures containing 2.5 to 3.5 per cent. copper and 2.0 to 3.0 per cent. zinc, 12 to 16 per cent. salt is used, the cinder containing 3.5 to 4.0 per cent. sulphur. Some cinders will carry as much as 4 to 6 per cent. in sulphur, owing to the high percentage of zinc.

Leaching.—To prevent the formation of lumps in the roasted ore, it receives a pre-leaching treatment in a special machine. In this apparatus the ore, in a thin layer, is evenly sprayed with just enough water so that the anhydrous sodium sulphate formed in the roasting will get water enough for crystallization, and so will become easily soluble. The ore, thus moistened, now remains in a powdery state. Part of the water thus applied to the hot ore forms steam, which, when condensed, gives

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hot water for leaching. The dust and steam formed within the apparatus is there confined, no longer escaping into the building. The machine runs continuously and furnishes a uniform product that leaches well. The product, when treated, is picked up by a grab-bucket and placed in the leaching tanks. These tanks, built of reinforced concrete, will hold 80 to 90 tons, and have an ore-bed 3 ft. deep. The time of leaching is about 20 hr. The leaching liquors are pumped by wooden centrifugal pumps that have been in use for two years. The tower-acid used in leaching will carry 1.5 to 2.0 per cent. HCl, and this strength gives thorough extraction. The purple ore after leaching is dug out with a grab-bucket, retaining but 0.07 per cent. Cu. In the European copper works, where the cinders are bought, the copper recovered is expected to pay expenses, and the profit lies in selling the purple ore.

Precipitation.—Solutions, preferably of a temperature of 30 to 40° C., and carrying 2.0 to 3.0 per cent. copper, go to storage-tanks, and thence to large closed revolving iron drums, suitably lined to prevent corrosive action of the copper-bearing liquors on the iron. Scrap iron is thrown into the drum, which is revolved for 30 to 60 min. with exclusion of air to prevent formation of basic iron compounds. The copper precipitate is then transferred to a filter-press, washed and discharged. The precipitate or cement copper contains 85 to 90 per cent. copper. The labor needed for 150 tons production in 24 hr. is 27 men, to which should be added the repair gang of 12 men, all working 8-hr. shifts. It should be added that in one European plant, operating in the old way, for a 300-ton production, 100 to 110 men were employed, working 12-hr. shifts.

Briquetting the Purple Ore.—This leached material, containing 55 to 68 per cent. iron, and not more than 0.01 per cent. phosphorus and 0.10 per cent. copper, must be briquetted for blast-furnace use. Presses, using the method of slow-compression, are used, giving strong briquets that are burned to give a uniform and solid product. Such a press has the capacity of 1200 briquets per hour. For burning, the tunnel furnace is employed, in which a temperature of 1450° C. is attained, thus driving off all remaining sulphur. For the production of 150 tons daily, two 75-ton furnaces are used. In 1914 the cost per ton of briquets was $0.60.[1]

Copper Precipitating Apparatus.[2]—Joseph Irving, Jr., has devised an apparatus, a modified Dorr thickener, for the precipitation of copper in a pregnant solution by means of scrap iron. As shown in Fig. 5, the vat, 24 ft. in diameter, has a conical or sloping bottom, a grated false bottom made of 4 by 4-in. slats, a central cylindrical down-take for the

[1] Viggo Carlsen (*Eng. Min. Jour.*, 111, 456), referring to copper ores with 20 to 25 per cent. silica, says that the chloridising roast would not be practicable, since the residual product would have no value as an iron ore.

[2] *Min. Sci. Press*, 123, 533 (1921).

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solution, and a peripheral discharge. Beneath the false bottom are provided power-driven stirring arms as in the Dorr thickener. The scrap iron is loaded into the vat by means of a gantry-crane upon the false bottom until the tank is full. In operation the solution is brought in by launder to the central down-take, and rises upward through the false bottom and through the scrap iron to the peripheral launder, entering it through holes bored through the sloping side. A discharge-launder takes the solution to other tanks in series, and so to waste. A baffle in the leaving-launder maintains a constant solution-level in the vat. To

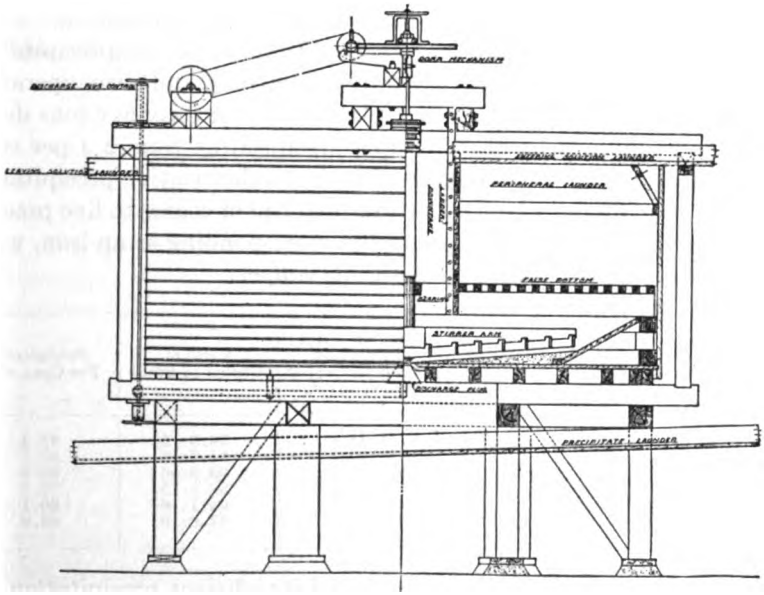

FIG. 5.—Copper precipitating vat.

wash the precipitate off the iron surfaces, the stirring mechanism is raised off the bottom and rotated at 5 r.p.m., so as to ensure effective agitation. This is done for one or two hours daily, about 5 hp. being needed. When the precipitate is to be discharged from the vat, this is done by lowering the stirring arms and slowly rotating them, so that the stirring blades plow the precipitate to the central discharge. This may be done daily, or even once a week, according to the amount of precipitate made, more in the first vats, little in the last ones of the series. It takes about two hours to discharge the precipitate through the central plug into a precipitate launder that delivers it to a Dorr classifier. Here two products are made, one the coarse precipitate, and the other an overflow of the fines carried by the solution. The coarse portion is dis-

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charged upon a drying platform, the fine overflowing to Dorr thickeners. Thus the slime is thickened before discharging upon its drying platform. The thickener overflow goes to a pump, to be pumped back to the precipitating vats. It is so arranged that some of this solution can be used to sluice out and wash the vats when necessary. The slime precipitate, which contains 80 to 90 per cent. of moisture on being discharged from the thickener, is left for about 10 days on a drying platform, and in that time is dried to about 35 per cent. moisture. The coarse precipitate will drain to 15 per cent. Scrap iron is brought in railroad cars to the plant and is discharged by a gantry-crane, either to the vats or to storage. For small scrap a magnet is provided.

A Dorr-system plant will cost about $2 per cu. ft. of precipitating capacity, and, due to its higher precipitation capacity and lower operating costs, is the cheapest system. In a plant recovering say five tons daily, five men per shift will be needed when precipitating from a 1-per cent. pregnant solution. The subjoined table shows the relative precipitating efficiency of the different kinds of scrap, the ratio of coarse to fine precipitate, and the percentage of copper in the corresponding scrap iron, when treating a solution containing 24 per cent. copper.

Precipitant.	Ratio by Weight of Iron Consumed to Copper Precipitated.	Ratio of Coarse to Fine.	Precipitate, Per Cent. Cu.
Pig iron	1.35:1	98.0: 2	94.4
Wrought iron	1.60:1	94.0: 6	87.2
Cast iron	1.65:1	93.5: 6	86.8
Steel shavings	2.10:1	86.5:13	72.7
Cast steel	1.75:1	94.1: 6	80.1
Tin cans	2.25:1	81.0:19	66.9

It will be seen that pig iron, because of its efficient precipitation, its high grade and the coarse condition of the precipitate, is to be preferred. Mr. Irving suggests the smelting of pig iron in a cupola furnace at some near-by smelting works, where calcines high in iron could be used. Such a pig iron need not be pure, and might even carry copper, reduced at the same time from the calcines. He estimates that the cost of producing such pig iron would be about $15 per ton.[2]

Leaching with Ammonia at Kennecott.[1]—The plant is now making a recovery of 82 per cent. of the copper from carbonate and oxidized ores. For handling the pregnant solutions, two sets of double-effect evaporators are employed, and so successfully that the amount of steam has been reduced by one-third. No longer do shut-downs occur from closing of

[1] The cost of production of pig iron at Chicago in November, 1921, has been estimated at $19.28 per ton, so that we should probably have to double Mr. Irving's figures to arrive at actual cost in some Western locality. L. S. A.

[2] *Min. & Met.*, Feb., 1921.

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the ports in the evaporators. The present ones will run continuously for two months and then need to shut down but two hours for repairs. The amount of ammonia (NH_3) is now ½ lb. per ton of dry material, and 350 lb. of steam only is needed on material carrying 1.1 per cent. copper carbonate.

In a special excavator used for the exhausted tailings, there are radial arms feeding downward, which empty a tank in 8 hr., employing 3 hp., and needing but little attention. The plant as now operated requires seventeen men to treat 18,000 tons per month, and the cost of producing the copper is 6 cts. per lb., f.o.b. Kennecott. Ammonia costs 50 cts. per lb., and the steam used 15 cts. per lb. when generated by oil at $4.10 per bbl. The labor costs are high and labor is not efficient.

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CRYOLITE

Cryolite, a mineral of the composition $3NaF.AlF_3$, is required in the production of aluminium, being used to dissolve or flux the pure alumina so that it may be melted at a temperature in the neighborhood of 1000°C. The cryolite is not decomposed by the electrolysis, which acts only on the alumina, so that the amount consumed is only that necessary to make up relatively small losses. The mineral is also used in the manufacture of opaque white glass, in the enameling of ironware, and in the manufacture of white Portland cement, but the amounts taken for these uses are small compared with the requirements of the aluminium industry.

The only commercial source of cryolite is the deposit at Ivigtut, Araukfjord, South Greenland, owned by Kryolith Mine and Handelsselskabet, A/S, Copenhagen, Denmark, which holds a state concession for the mining. The shipments go to two selling agents, Oresunds Chemiske Fabriker, Kommanditselskab ved C. F. Jarl, of Copenhagen, and the Pennsylvania Salt Manufacturing Co. of Philadelphia, Pa. The amounts of the shipments since 1914 have been as follows, in metric tons:

	To the United States.	To Copenhagen.	Total.
1914	4,139	7,373	11,512
1915	3,753	5,809	9,562
1916	3,773	9,812	13,585
1917	3,959	5,678	9,637
1918	1,916	8,802	10,118
1919	1,973	4,394	6,367
1920	5,024	8,904	13,928
1921	5,200	6,118	11,318

The Department of Commerce reports the following imports for the corresponding years:

	Long Tons.	Value.	Value per Ton.
1914	4,612	$ 94,424	$20.47
1915	3,940	82,750	21.00
1916	3,857	165,222	42.83
1917	4,383	218,500	49.85
1918	1,950	97,500	50.00
1919	2,131	106,956	50.20
1920	3,864	193,638	50.11
1921	3,460	295,186	85.31

Part of the United States imports are re-shipped to Canada, mainly for use in the Canadian aluminium industry. The Canadian imports,

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almost entirely from the United States, are as follows (for fiscal years ending March 31 of the succeeding calendar year):

	Short Tons.	Value.	Value per Ton.
1914	1,075	$ 44,683	$ 41.56
1915	1,765	72,024	40.81
1916	860	87,146	101.33
1917	685	131,236	191.49
1918	732	137,258	187.43
1919	839	137,702	164.12
1920	865	153,500	177.45
1921	108	22,196	205.52

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FELDSPAR

By Arthur S. Watts

The feldspar industry has shown marked activity during the year 1921 although not evidenced by production records. Mining activity has been evidenced by the opening of new deposits and grinding operations have been evidenced by the erection of several new mills and the increased and improved equipment of many others.

In Maine no new mining companies have been reported, but the established concerns are continuing their activities.

In New Hampshire, a new feldspar-mining industry has been established in connection with the Keene Mica Products Co. at Alstead near Keene, N. H. At the mica mines of this company, large deposits of feldspar have been located and the Golding-Keene Co. has been organized to mine and grind this material.

No new developments are reported in Connecticut, New York, Pennsylvania or Maryland.

In North Carolina, there is considerable activity in mining, both in Mitchell and Yancey counties. Reports from the field indicate that there is an increasing demand for only the best grade of feldspar, and since North Carolina is now the largest producer of crude feldspar, the market is evidently being satisfied with high-grade material.

California continues to produce a very small tonnage and Colorado was also a small producer in 1921.

Canada in 1921 produced about 75 per cent. of its tonnage of 1920, the demand falling off during the latter part of the year. The bulk of the Canadian production comes from the Verona district of Ontario. A very promising deposit was opened during the year in the Buckingham district, Quebec, and several thousand tons shipped. Practically all the feldspar mined in Canada is shipped to the United States, the English market being monopolized by the Scandinavian feldspar. Canada does not consume more than 5000 tons of ground feldspar per year. The reputation of Canadian feldspar suffered during the year owing to numerous shipments of inferior material. Many new properties are reported in the operating district and some of these will doubtless be opened during the coming year. The reopening of an old property in the Verona district, which has been closed for several years on account of litigation, is also expected to add to the production.

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CRUDE FELDSPAR PRODUCTION (a)
(In long tons)

	1919.	1920.	1921. (d)
United States:			
California	(b)	1,021	(c)2,100
Connecticut	9,715	7,719	8,800
Maine	12,845	45,352	16,000
Maryland	6,982	17,999	5,200
New Hampshire	.....	.....	(b)
New York	(b)	19,294	(b)
North Carolina	22,495	36,521	53,400
Pennsylvania	(b)	7,645	(b)
Undistributed	11,404	.....	15,500
Dominion of Canada	13,345	34,430	27,764

(a) U. S. data from U. S. Geol. Surv.; Canadian data from Can. Dept. of Mines. (b) Included in "undistributed" to conceal individual production. (c) Includes a small production from Colorado. (d) Estimated.

TOTAL FELDSPAR PRODUCTION AND VALUES

	United States.		Canada.		Norway.	Sweden.
	Short Tons.	Value.	Short Tons.	Value.	Short Tons.	Short Tons.
1913	120,955	$776,551	15,935	$56,841	45,020	41,753
1914	135,419	629,873	18,060	70,824	30,828	22,948
1915	105,118	489,223	15,455	59,124	9,676	13,343
1916	132,681	702,278	19,488	71,407	14,122	14,026
1917	141,924	728,838	19,642	89,826	4,889	20,429
1918	99,120	674,346	18,782	112,728	3,845	19,676
1919	71,054	585,200	14,679	86,231	Nil.	14,225
1920	149,106	1,250,000	37,873	280,895	Nil.	.....
1921	111,100	700,000	30,540	223,000	.....	.....

The value of the crude feldspar averaged about $6.25 per ton, while the prevailing price for best ground feldspar averaged about $22.00 per ton.

The greatest constructive step in the feldspar industry in recent years began about the end of the year when an open meeting between producers and consumers was called by the American Ceramic Society for Mar. 1, 1922, to which all interested parties were invited, with the hope that improvement in quality and uniformity, and decrease in cost of mining and milling, might result. At the present time feldspar is being mined by the most primitive methods in some localities while at other properties the most approved methods are employed. Likewise some mills crush with the primitive roll-crusher, while others employ the more modern jaw-crusher, and in a few cases ball-mills are used for preliminary grinding. The final pulverization is accomplished in different mills by pebble-mills, tube-mills, and conical mills. Several mills grind wet, although dry grinding generally prevails. All claim that their product is of first quality and it appears that some definite information is necessary before the consumer will abandon his preference for feldspar ground by the more primitive method, which theoretically is declared unduly expen-

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sive, although no directly comparable data are available on this subject. This controversy has developed much interest and promises practical results.

During the year 1921 several mills were erected for grinding feldspar. The list of operating mills at present is as follows:

Bedford Mining Co., Bedford, N. Y., operating two mills at Bedford, N. Y., and grinding Westchester County, New York, soda and potash feldspars.

Carolina Feldspar Co., Asheville, N. C., operating a mill at Micaville, N. C., and grinding North Carolina feldspar.

Clinchfield Products Corporation, 120 Broadway, New York, N. Y., operating a mill at Erwin, Tenn., and grinding North Carolina feldspar.

Cummings, J. W., Feldspar Co., Bath, Me., operating a mill at Bath, Me., and grinding Maine feldspar.

Dominion Feldspar Co., Barnard, N. Y., operating a mill at Genesee Docks, N. Y., and grinding Canadian feldspar.

Erwin Feldspar Corporation, Erwin, Tenn., operating a mill at Erwin, Tenn., and grinding North Carolina feldspar.

Eureka Flint and Spar Co., Trenton, N. J., operating a mill at Trenton, N. J., and grinding Connecticut, New York, North Carolina and Canadian feldspars.

Golding-Keene Co., Keene, N. H., operating a mill at Keene, N. H., and grinding New Hampshire feldspar.

Golding Sons Co., Trenton, N. J., operating mills at Trenton, N. J., Wilmington, Del., and East Liverpool, Ohio, and grinding Maine, Maryland, North Carolina and Canadian feldspar.

Howe, L. W., South Glastonbury, Conn., operating a mill at South Glastonbury, Conn., and grinding Connecticut feldspar.

Maine Feldspar Co., Brunswick, Me., operating mills at Topsham and Auburn, Me., and grinding Maine feldspar.

Mount Eagle Feldspar Co., 327 Union Bldg., Cleveland, Ohio, operating a mill at Cleveland, Ohio, and grinding Canadian feldspar.

Pennsylvania Pulverizing Co., Lewistown, Pa., operating a mill at Rochester, N. Y., and grinding Canadian feldspar.

Products Sales Co., 32 S. Calvert St., Baltimore, Md., operating a mill at Baltimore and grinding Maryland feldspar.

Rock Products Co., Nicholas Bldg., Toledo, Ohio, operating a mill at Silica, Ohio, and grinding Canadian feldspar.

Trenton Flint & Spar Co., Trenton, N. J., operating mills at Cathance, Me., and Trenton, N. J., and grinding Maine feldspar.

Wheeling Pulverizing Co., Wheeling, W. Va., operating a mill at Wheeling, W. Va., and grinding Canadian feldspar.

Willms, Carl, Erwin, Tenn., operating a mill at Erwin, Tenn., and grinding North Carolina feldspar.

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FLUORSPAR[1]

By Hubert W. Davis

Due to the lack of demand as a result of large stocks of fluorspar in the hands of consumers at the beginning of 1921, together with the general depression in the industries that consume fluorspar, the shipments in 1921 decreased 81 per cent. in quantity and 85 per cent. in total value as compared with 1920. The shipments in 1921 were the lowest recorded since 1908.

FLUORSPAR SHIPPED FROM MINES IN THE UNITED STATES (a)
(In short tons)

State.	1920.			1921.		
	Quantity.	Value.	Average per Ton.	Quantity.	Value.	Average per Ton.
Colorado	12,852	$251,308	$19.55	3,143	$39,907	$12.70
New Mexico	6,353	101,460	15.97	3,507	60,186	17.16
Illinois	120,299	3,096,767	25.74	12,477	315,767	25.31
Kentucky	46,091	1,246,942	27.05	15,266	294,513	19.29
Nevada, New Hampshire, Utah, Arizona	1,183	22,070	18.66	567	13,721	24.20
	186,778	$4,718,547	$25.26	34,960	$724,094	$20.71

(a) Statistics of U. S. Geol. Surv.

SALES OF FLUORSPAR IN THE UNITED STATES, IN SHORT TONS (a)

Year.	Quantity.	Value.	Year.	Quantity.	Value.
1907	49,496	$287,342	1915	136,941	$764,475
1908	38,785	225,998	1916	155,735	922,654
1909	50,742	291,747	1917	218,828	2,287,722
1910	69,427	430,196	1918	263,817	5,465,481
1911	87,048	611,447	1919	138,290	3,525,574
1912	116,545	769,163	1920	186,778	4,718,547
1913	115,580	736,286	1921	34,960	724,094
1914	95,116	570,041			

(a) Statistics of U. S. Geol. Surv.

Fluorspar Industry by States

Arizona.—On account of the low price of fluorspar in 1921 the producers in Arizona were unable to compete profitably for the small quan-

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tity that was required by western consumers. A little fluorspar was mined, but no shipments were reported.

Colorado.—Operations were curtailed at both Wagon Wheel Gap and Jamestown, Colo., the Lehman mill, at Jamestown, being closed about Feb. 1, and the mine at Wagon Wheel Gap, May 1.

Illinois.—The concentrating mill of the Rosiclare Lead & Fluorspar Mining Co. was redesigned and rebuilt in order to improve mill practice on the ores. The additions made include a large machine to de-water the mill feed and separate the silicious slimes, a larger and more complete screening and sizing system to assist the jigs in making cleaner separation, and tables to handle the fine sand spar, heretofore handled on jigs. Provision has also been made for handling spar middlings and re-treating them in order to keep down the tailing losses and to produce a better grade of gravel from the jigs.

At the Eichorn mine, near Rosiclare, the shaft was sunk to a depth of 200 ft. and crosscuts were made to the vein at the 100-ft. and 200-ft. levels. Drifts are being run at the 200-ft. level, and some fluorspar has been taken out. Work on a small milling plant has been begun.

Construction and development work at the Hillside mine and mill, near Rosiclare, was continued throughout the year, and it is expected that this modern plant will be put in operation in 1922.

Exploration work was done at two openings on the property of the Spar Mountain Mining Co., near Cave-in-Rock.

The Cave-in-Rock Fluorspar Co. abandoned its property near Cave-in-Rock. This company acquired the Baldwin mine, near Elizabethtown, in Pope County, sunk a shaft and installed a crusher and log-washer. A small quantity of fluorspar was mined and shipped in 1921.

Kentucky.—The shipments from Kentucky in 1921 exceeded those of Illinois for the first time since 1904.

The Ohio-Kentucky Fluorspar & Lead Corporation has taken over the Klondyke and Royal mines, near Smithland. It is reported that the Klondyke mine is now fully developed and has a 10-ft. vein at the 160-ft. level and that an up-to-date 100-ton mill is to be built during 1922. The shaft at the Royal mine, which has not been fully developed, is said to be about 400 ft. deep. A mill having a daily capacity of 250 tons is planned.

The Tabb and Wheeler mines, near Mexico, Ky., were acquired late in 1921 from the West Kentucky Ore Co. by the Kentucky Fluorspar Co. At the Tabb mine two new shafts were sunk which show an average of 6 ft. of high-grade fluorspar at a depth of 70 ft., at which 200 ft. of drifting has been done. Two new shafts were sunk to a depth of 70 ft. at the Wheeler mine. No. 2 shaft on the extension of the Yandell vein was

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sunk to a depth of 90 ft. by the Kentucky Fluorspar Co. and a large body of acid-grade fluorspar was reported to have been encountered.

The Lucille mine of the Gugenheim Mining Co. at Marion, the only mine except the Haffaw in western Kentucky with railroad connection, exhausted its No. 3 shaft which was sunk late in 1920 to reach a pocket containing about 5000 tons of fluorspar. This company will continue to operate its mill at Marion and will draw its supply from mines near Mexico, about 8 miles to the south.

The Crystal Fluorspar Co. did considerable development work at its property near Sheridan and reports having opened a vein of high-grade fluorspar.

It is reported that many small operators abandoned the western Kentucky field entirely during 1921, leaving their workings to fill with water and the shafts to cave in, thus losing all development work done during the last few years.

The Heyward Minerals Co., which has mines in the central Kentucky district, operated during the first quarter of 1921, suspended work for six months, and then resumed in October.

Nevada.—The Continental Fluorspar Co. suspended hoisting at its mine near Beatty, Nev., but expected to resume operations early in 1922. A washing and grinding plant consisting of engines, crusher, tables, grinders, and dryers was installed.

New Hampshire.—New Hampshire was the only producing State that showed an increase in shipments in 1921. The output was obtained from the Pierce and Stoddard mines, in Cheshire County.

New Mexico.—The new mill of the Great Eagle Fluorspar Co., in Grant County, N. Mex., was completed and put in operation, and a small quantity of ground fluorspar was shipped. Another new mill, that of the Ore Production Co., near Rincon, was also put in operation. At the Tortuga mine of the American Fluorspar Co., near Mesilla Park, Dona Ana County, a jig has been added to the mill, which now has a capacity of 15 tons of ground fluorspar every 24 hr., and a considerable quantity of ground fluorspar was shipped during the year. It is reported that a vein of fluorspar carrying 97 to 98 per cent. of calcium fluoride was opened at the Tortuga mine.

From the middle of 1920 until October, 1921, the Hibbs Ore Co. exploited, developed, and experimentally treated ores of about 10 mines in the fluorspar field of New Mexico. It is reported that a new dry process was developed whereby any grade of crystalline ore could be treated so as to yield more than 90 per cent. of its fluorspar content and produce a 90-per cent. grade, at a cost of about $1.25 a ton.

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Utah.—A small quantity of fluorspar was mined by the Fluorite Mines Co. near Clive, Utah, in 1921, but no shipments were made, as the consumers who draw their supplies from this mine had sufficient material on hand for their requirements.

IMPORTS

The imports of fluorspar into the United States in 1921 showed a decrease of 75 per cent. in quantity and 74 per cent. in value compared with 1920. The imports in 1921 were equivalent to about 25 per cent. of the domestic shipments of gravel fluorspar, as compared with about 16 per cent. in 1920. Of the imports in 1921 Canada furnished 70 per cent., practically all of which came from the Rock Candy mine in British Columbia, England 26 per cent., and Germany 4 per cent.

FLUORSPAR IMPORTED, IN SHORT TONS (*a*)

	Quantity.	Value.	Average Price per Ton.
1912	26,176	$71,616	$2.74
1913	22,682	71,463	3.15
1914	10,205	38,943	3.82
1915	7,167	22,878	3.19
1916	12,323	54,000	4.38
1917	13,616	114,598	8.42
1918	12,572	169,364	13.47
1919	6,943	107,631	15.50
1920	24,612	265,630	10.79
1921	6,229	69,306	11.13

(*a*) Statistics according to Bureau of Foreign and Domestic Commerce, Department of Commerce.

FOREIGN COUNTRIES

Canada.—The total shipments of fluorspar in Canada in 1921 amounted to 5519 short tons, valued at $136,267, as compared with 11,235 tons, valued at $240,446 in 1920.[1] With the exception of 116 tons, valued at $1744, all of the fluorspar shipped in 1921 was furnished by the Consolidated Mining & Smelting Co., who operate the Rock Candy mine near Grand Forks, B. C. A part of the fluorspar produced in Canada is used in that country, but the greater part, 4625 tons, valued at $51,470, was exported, most of which, if not all, was sent to the United States. The imports of fluorspar into Canada in 1921 amounted to 3867 tons, valued at $43,752.

Japan.[2]—Fluorspar is produced in small quantities at Ishikure, in Ise Province, and also at Hotatsusan, in Noto Province. The domestic product is of such poor quality, however, that the greater part of the demand is supplied from foreign sources, principally Korea, Manchuria, and South China. So far as can be ascertained, none is imported from the United States.

[1] Prelim. Rept. Min. Prod. of Canada, 1921, Dominion Bur. of Statistics.
[2] *Comm. Rept.*, Feb. 27, 1922.

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The grade used varies from CaF_2 of 50-per cent. quality, secured from Shinmaku, in Korea, to CaF_2 of 80 to 85 per cent., secured from South China. That which grades 80 per cent. or more is generally required in the local steel industry, although the Mitsubishi Co. uses a 50-per cent. grade at the Kenjiho works. Fluorspar of 65 to 70 per cent. is utilized in the manufacture of glass and enamel ware. A certain amount is utilized at the Kamioka mine of Mitsui & Co. and also at the Osaka Electric Refinery of the Mitsubishi Co.

The total amount of fluorspar used in the Japanese steel industry during 1920 was 230 metric tons.

Because of the small amount imported, fluorspar is not listed separately in the Japanese trade statistics, nor has it been possible to secure this information from other sources. It is probable that the total importation for all use will not exceed 300 tons, including the amounts received from Korea. Due to the depression in the steel industry and the competition of near-by producers, who are more favorably situated in regard to transportation costs, prospects are not very encouraging for the importation of the American product.

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FULLER'S EARTH

The output of fuller's earth in the United States in 1921 was 105,609 short tons, valued at $1,973,848, according to the United States Geological Survey. The quantity decreased 18 per cent. and the value 21 per cent. as compared with 1920. In 1921 the average value per ton at the mine was $18.69; in 1920 it was $19.51. Fuller's earth is found in many states, but in 1921 it was mined only in Alabama, Arkansas, Florida, Georgia, Massachusetts, and Texas. Florida has been the leading State in production ever since the industry was established in this country, in 1895, and in 1921 it made 54 per cent. of the total output. Georgia and Texas were second and third, respectively, in output and value.

STATISTICS OF FULLER'S EARTH IN THE UNITED STATES (a)
(In tons of 2000 lb.)

Year.	Production.		Imports.		Year.	Production.		Imports.	
	Sh. Tons.	Value.	Sh. Tons.	Value.		Sh. Tons.	Value.	Sh. Tons.	Value.
1908.....	30,517	$270,685	12,279	$93,413	1915.....	$47,901	489,219	19,441	$152,493
1909.....	29,561	289,000	12,752	101,151	1916.....	67,822	706,951	15,001	139,664
1910.....	30,857	277,293	16,857	132,545	1917.....	72,567	772,087	16,994	176,417
1911.....	34,668	335,350	18,224	143,594	1918.....	84,468	1,146,354	16,920	226,235
1912.....	32,715	305,522	19,109	145,337	1919.....	106,145	1,998,829	13,873	189,711
1913.....	33,594	369,750	18,628	145,588	1920.....	128,487	2,506,189	19,235	221,893
1914.....	40,981	403,646	24,974	195,083	1921.....	105,609	1,973,848	9,744	119,415

(a) U. S. Geol. Surv.

United States Deposits.[1]—Clays having the properties of fuller's earth are widely distributed in the United States and are confined to no particular geological horizon, although the largest known deposits belong to the Cenozoic Age. By far the greater part of fuller's earth occurs as a distinctly stratified sedimentary deposit, from which an overburden must be removed in mining. In Arkansas, however, some fuller's earth is known which is of exceptional occurrence in that it is residual, having been formed in place from the disintegration of basaltic dikes.

The fuller's earth of southern Georgia, which is worked at Attapulgus, near the Florida line, represents a northward extension of Florida deposits. In central Georgia near Macon, however, is found a different type of fuller's earth, which, according to the Georgia Geological Survey, is the Claiborne formation of the Eocene. This mineral differs in some important respects from that of Florida, being used chiefly for the clarification

[1] S. L. Lloyd, *Eng. Min. Jour.*, Nov. 26, 1921.

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of vegetable oils, whereas the Florida grade finds its chief application at present in the clarification of mineral oils. The fuller's earth of Arkansas is also used chiefly in clarifying vegetable oils. The fuller's earth of Colorado is said to be used in bleaching cottonseed oil, and that of Massachusetts is used in fulling woolen goods. The fuller's earth of California is used, according to the state mineralogist, as a clarifying agent in the refining of crude oil.

Florida is practically the chief producer of fuller's earth in the United States. The deposits being worked are those of Gadsden County, in northern Florida, and of Manatee County, in the southern part of the State, the mineral being found at both localities in the Alum Bluff formation of the Upper Oligocene.

Imports.—The imports of fuller's earth in 1921 were 9744 short tons, valued at $119,415, a decrease of 49 per cent. in quantity and 46 per cent. in value as compared with 1920, the lowest quantity since 1900, and only a little more than a third of the maximum, which is credited to 1914. The average value per ton of imported earth at the principal markets of the country from which it was exported was $12.26 in 1921 as compared with $11.54 in 1920.

FULLER'S EARTH IMPORTED AND ENTERED FOR CONSUMPTION IN THE UNITED STATES (a)

Year.	Unwrought or Unmanufactured.			Wrought or Manufactured.			Total.		
	Quantity (Short Tons).	Value.	Average Price per Ton.	Quantity (Short Tons).	Value. ($)	Average Price per Ton.	Quantity (Short Tons).	Value. ($)	Average Price per Ton.
1911.....	1,881	$10,877	$5.78	16,343	132,717	$8.12	18,224	143,594	$7.88
1912.....	1,970	11,619	5.90	17,139	133,718	7.80	19,109	145,337	7.61
1913.....	1,916	12,344	6.44	16,712	133,657	8.00	18,628	146,001	7.84
1914.....	1,468	9,283	6.32	23,509	185,800	7.90	24,977	195,083	7.81
1915.....	850	5,176	6.09	18,591	147,317	7.92	19,441	152,493	7.84
1916.....	1,132	7,742	6.84	15,669	131,922	8.42	16,801	139,664	8.31
1917.....	1,441	11,718	8.13	15,553	164,699	10.58	16,994	176,417	10.38
1918.....	900	10,502	11.67	11,707	155,033	13.24	12,607	165,535	13.13
1919.....	373	4,301	11.53	13,500	185,410	13.73	13,873	189,711	13.67
1920.....	1,738	19,793	11.38	17,497	202,100	11.55	19,235	221,893	11.54
1921.....	483	6,172	12.78	9,261	113,243	12.23	9,744	119,415	12.26

(a) Bureau of Foreign and Domestic Commerce.

Great Britain.[1]—England was formerly the chief producer of fuller's earth, and exported it in large quantities. Deposits have been worked in Great Britain in a number of places, but at the present time the largest works is situated near Reigate, Surrey, where the large quarry owned by the Fuller's Earth Union, Ltd., employs upwards of 45 men. The quarry of the Surrey Fuller's Earth Co., Ltd., at Nutfield in the same district, is next in importance, and there are three mines in active operation at the present time in the same neighborhood.

[1] Fuller's Earth, Imperial Mineral Resources Bureau, London.

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Following are the outputs of fuller's earth in Great Britain in recent years:

Year.	Long Tons.	Year.	Long Tons.
1913	31,609	1917	27,916
1914	37,862	1918	23,290
1915	29,298	1919	24,785
1916	29,106	1920	28,906

Mining and Preparation[1]

All the sedimentary deposits of fuller's earth are mined by the open-pit method, the overburden being removed by steam-shovel in the larger mines and by mule-team and scraper or pick and shovel in the smaller ones. The depth of overburden that can profitably be removed is variable, depending, as it does, upon the thickness and quality of the fuller's earth stratum beneath and upon the character of the overburden itself. In the Florida mines the maximum overburden removed is from 12 to 14 ft. thick. This consists of sand, clay, and in some cases marl. The fuller's earth in these mines includes two strata, each from 6 to 10 ft. thick, and separated by a thin stratum of sandy or calcareous material. As a rule only the first stratum is worked. The fuller's earth itself is dug with pick and shovel, and loaded on to cars to be drawn to a plant, where it is broken up by passing through a crusher, thus facilitating both handling and drying. Although the material is usually taken directly to the crusher, in some instances it is placed in storage-bins and air-dried before being crushed.

The driers employed are for the most part rotary cylinders. Those in use in Florida are 40 to 60 ft. long and about 6 ft. in diameter. When in operation they rotate slowly, the mineral being moved along by means of flanges attached to the inside of the cylinder. These cylinders are heated to a moderate temperature by oil burners, the heat being applied either at the end where the wet earth enters, or at the opposite end, from which the dry earth escapes. No precautions are necessary to prevent overheating in these plants, as the earth is used for filtering mineral oils, but when fuller's earth is to be used for edible oils precautions are taken to avoid overheating, as driving off the combined water is supposed to be injurious. To guard against overheating, especially constructed rotary cylinders are used, or the mineral is run into brick form and dried in tunnel driers through which hot air is forced. Although the English fuller's earth is injured by driving off the combined water, it has been found that some of the American earths bleach fully as well after the combined water is

[1] S. L. Lloyd, *Eng. Min. Jour.*, Nov. 26, 1921.

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removed. It is probable that precautions against overheating for the use of edible oils are sometimes unnecessary.

In grinding, a variety of mills are in use. After grinding, the fuller's earth is bolted. That intended for refining petroleum is bolted to a definite size and placed on the market graded as 15 to 30 mesh, 30 to 60 mesh, and 60 to 80 mesh. The coarser sizes are in most demand, and as a rule no market exists for material passing 90 mesh, which is not infrequently a total loss, being thrown into the dump. For edible oils it is said that fuller's earth should be ground to pass 100 mesh, but that there should not be an excess of exceedingly fine material, which would clog the pores of the coarser material and prevent successful filtering. The grades differ in the degree of fineness to which they can be successfully ground. Whereas English fuller's earth is ground to 120 mesh without having an excess of very fine particles, much of the American mineral cannot be ground finer than 100 mesh, for edible oils. It is true also that the mill employed must be adapted to the particular fuller's earth for which it is to be used.

Most fuller's earth imparts more or less taste to the edible oils, and formerly American grades were rejected by refiners of edible oils on this account, but methods are now known for removing taste and odor from the oil by blowing dry steam through the refined oil heated to a temperature above the boiling point of water. A serious difficulty in its use is the rapid oxidizing action which some fuller's earths have on edible oils. In milling practice, air is blown through the filter-press to force out the oil remaining in the fuller's earth after treatment. With some of it, the oxidizing action is so rapid that the oil remaining in the mineral takes fire, or is liable to take fire. It is hoped that this difficulty will be overcome.

Fuller's earth used in clarifying mineral oils, which includes by far the greater part of that produced in America, is sold at the mine, ground, bolted and sacked for shipment. That used for refining vegetable oils brings a somewhat higher price, as more expense is incurred in handling the material, as it must be ground finer for vegetable than for mineral oils.

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GOLD AND SILVER

By M. W. von Bernewitz

Introduction.—The past year witnessed no unexpected events in gold and silver mining. Another drop in production was predicted, largely on account of the world-wide shut-down of many copper, lead, and zinc mines; further closing of worked-out mines; and prevailing abnormal conditions affecting others. Costs are still high, although there is a downward tendency in prices of materials and wages. Somewhat improved international conditions have advanced exchange nearer normal, so that gold producers in the British Empire get less for their product; but this was to be expected. And while much effort was made to get a bonus for newly mined American gold, it is almost certain that Congress will not pass the Bill; therefore, domestic producers must wait patiently until conditions return to what might be considered normal. The one bright spot on the gold-mining horizon is Ontario, where production grows, and no such thing as a bonus has been suggested, although the companies operating there received a premium on selling their gold in the United States. There were numerous miners' strikes in the gold fields of the United States, Australia, Rhodesia, and the Transvaal, all of which affected the general output. There is this to be said about gold mining, that at the end of 1921 and early in 1922, this industry had the brightest outlook of any metal with every prospect of continuing so, save in the case of silver mining, which, however, is temporarily stimulated by a high fixed price for the metal.

Gold

In his "Our Vanishing Gold Production,"[1] H. N. Lawrie, economist for the American Mining Congress at Washington, D. C., presented the following tables, to which we have added the figures for 1921.

GOLD PRODUCTION.

	World.	United States.	United States to World, Per Cent.
1915	$468,724,918	$101,035,700	21.5
1916	444,176,500	92,590,300	20.4
1917	419,422,100	83,750,700	20.0
1918	383,605,552	68,646,700	17.9
1919	365,788,796	60,333,400	16.5
1920	334,987,610	51,186,900	15.3
1921	327,000,000	49,105,500	15.0

[1] *Mining Congress Jour.*, Dec., 1921.

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ANNUAL DECLINES IN GOLD PRODUCTION

Period.	World.	Per Cent.	United States.	Per Cent.	World, Excluding United States.	Per Cent.	United States' Proportion of World's Decline, Per Cent.
1915–16.....	$24,548,418	3.1	$8,445,400	8.3	$16,103,018	4.4	34.4
1916–17.....	24,754,400	7.7	8,839,600	9.5	15,914,800	4.5	35.7
1917–18.....	35,816,548	8.5	15,104,000	18.0	20,712,548	6.2	42.2
1918–19.....	17,816,756	4.6	8,313,300	12.1	9,503,456	3.0	46.6
1919–20.....	30,801,186	8.4	9,146,500	15.1	21,654,686	7.1	29.7
1920–21.....	11,000,000	3.3	2,081,400	4.1	8,919,000	2.6	18.9
1915–21.....	$144,737,308	30.2	$51,930,200	51.4	$92,807,508	24.4	35.9

Mr. Lawrie stated that the principal reason for the extensive decline in gold production throughout the world has been the increased cost of labor and material since 1915 as against a fixed price for gold; but there has been a factor in all countries outside of the United States which has in a large measure compensated for these increased costs since 1919, and that is the free market for gold whereby British producers received an additional price in paper currency measured by the discount in exchange. In the United States the paper currency has not been at a discount, and consequently producers of gold received no compensation to offset their increased costs.

Discussing domestic conditions in order, it will be remembered that the McFadden Bill—H. R. 13201—died with the 66th Congress in March, 1921, but another Bill—H. R. 5025—sponsored by the same member, was substituted therefor in the 67th Congress, on April 26. Its purpose was the same, namely, to provide for the protection of the monetary gold reserve by the maintenance of the normal gold production of the United States, by imposing an excise (50 cts. a pennyweight of fine gold contained in manufactured articles, to be collected at the time of sale), for revenue and other purposes, upon all gold used for other than monetary purposes, and by the payment of a premium (50 cts. a pennyweight) to the producers of newly mined gold, and providing penalties for the violation thereof. The period for this act was to be three years, in place of five in H. R. 13201; and another difference was that whenever in the judgment of the Secretary of the Treasury economic conditions are such that a normal production of gold within the United States and its possessions can be maintained without the premium provided for, the provisions of the act shall be discontinued, effective three months after the issuance of notice thereof by the Secretary.

As it was felt that the attitude of the Treasury for or against the Bill would in effect determine its fate, J. F. Callbreath, secretary for the American Mining Congress, on May 16, wrote to the Secretary of the

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Treasury and explained the condition of the gold-mining industry and the probable effect upon it if no aid were rendered by means of the proposed premium.

On Aug. 17, twenty-two Senators from Western mining states addressed a note to the Secretary of the Treasury, requesting that if upon his analysis of the Bill H. R. 5025 reasons could not be definitely assigned for opposing its provisions, he endorse the same in order to expedite the action of the House and permit the bill to be considered by the Senate; and further, that if he had specific reasons for opposing the provisions of the Bill, he was urgently requested to formulate a proposal for enactment by Congress; first, to protect the gold-mining industry from destruction, which is a serious matter irrespective of the fact that its operation is necessary as the basis of our monetary system; and second, in anticipation of the heavy foreign drain upon our gold reserve, to provide for augmenting the said reserve from sources of domestic production, and thereby lessen the need for the further and extensive curtailment of credit which otherwise would result.

The Secretary of the Treasury replied on Sept. 30, saying that the Treasury's position with respect to this Bill had already been stated in his letter of May 9, 1921, to J. W. Fordney, chairman of the House Committee on Ways and Means, which was to the effect that in a sense this is the penalty which gold pays for being the standard. The difficulties should gradually adjust themselves without a Government subsidy as deflation progresses and commodity prices return toward normal. As the Secretary of the Treasury saw it, the question of whether the Government is to give a bonus on these terms to a special class of producers is a question of policy which addresses itself to the judgment of Congress, and not a question upon which the Treasury is in a position to express an opinion; also that no legislation of this character was needed and the Treasury had no proposal to submit for a bonus. The Secretary of the Treasury in this letter of Sept. 30 also said that the developments which had occurred since his letter of May 9 was written had confirmed the Treasury's views, and had shown that as commodity prices return toward normal and costs become established on a lower level, relief should gradually come in the ordinary course of events from the difficulties of which the gold-mining industry has been complaining. Already there were signs of some improvements.

Senator Tasker L. Oddie of Nevada replied to the Secretary of the Treasury on Oct. 19, discussing all the points raised by the latter, and concluding that the proposed constructive gold policy put into effect would safeguard the maintenance of the gold standard, and also aid in reviving domestic industry and export trade. To this letter the Secretary

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has not replied, so it may be inferred that the McFadden Bill H. R. 5025 is dead. Meanwhile gold mining is steadily improving.

In its published replies[1] to an interrogatory on metal-mining conditions throughout the United States, question No. 3 under gold was, "Should the McFadden Bill fail to pass, will it seriously affect existing gold mines and militate against prospecting and development of new properties?" Of twelve engineers who replied to this question, five said yes, five said no, or its equivalent, while two were non-committal.

There were six other questions asked. No. 1 was, "Is gold mining expanding by reason of the general lowering of the cost of production?" Five replied yes and five no, while two were doubtful. Three considered that Cripple Creek was expanding.

Question No. 2 was, "Have the gold mines in your district that were shut down by reason of high operating costs during the war period resumed activity?" One replied yes, but eight said no, while four announced part resumption. Two mines of a company included in part resumption were dismantled during the period.

In answer to questions No. 4, 5, 6, and 7, it was generally stated that managers were considering ways and means of reducing operating costs by installing more modern and economical equipment, certain machinery needed improving, and there was a tendency to substitute mechanical for hand labor wherever possible, especially with underground loading devices.

The present status of the world's gold and silver production, a historic and economic review of the precious metal, was discussed by R. H. Tingley.[2] This was a well-illustrated paper, and included a number of graphs showing production, prices, bullion value of silver in a silver dollar, commercial ratio of silver to gold, and stock of gold and silver money in the United States. The anomaly of gold production and the McFadden Bill lies in the fact that the price of gold is fixed, and mining is unprofitable, save in a few instances of large-scale operation; therefore Mr. Tingley considers that the proposed bonus would remedy the situation. The anomaly of silver production and the Pittman Act lies in the fact that the once fluctuating price for this metal is now fixed at $1 an ounce for American mines until the 270,121,554 silver dollars in the Treasury sold as metal to India are replaced, which will not be completed for another two years at the least.

A world atlas of commercial geology was published by the U. S. Geological Survey during the year. Part 1, entitled "Distribution of Mineral Production," consisted of 72 pages of text and 72 full-page (10½ by 13½ in.) maps. The section on gold and silver includes 2 pages of text and 8 maps. The occurrence and methods of treatment of ores and

[1] *Min. Sci. Press*, **123**, 508 (1921).
[2] *Compressed Air Mag.*, **27**, 21 (1922).

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production figures are briefly discussed; by means of colored lettering and signs, the principal producing fields of the world and their proportion of the world's total are indicated on the maps. The atlas is a reliable and useful reference.

A world map of precious stones and precious metals was published[1] during 1921, and from a popular standpoint it is fairly instructive. The position of the various fields is indicated by a color scheme and shading. Some information is blocked in regarding dates of gold discoveries and the status of producing countries.

The story of gold, told in popular style by John Hays Hammond, appeared in *The Mentor* for January, 1922. The article was well illustrated, showing progress in the art of working gold centuries ago, also photographs of modern hoisting shafts, mills, and dredges.

GOLD AND SILVER PRODUCTION OF THE WORLD, 1493–1850
According to Dr. Adolph Soetbeer

Period.	Estimated Production in Kilograms.		Ratio of Silver to Gold. Weight.	Ratio of Gold to Silver. Value.	Period.	Estimated Production in Kilograms.		Ratio of Silver to Gold. Weight.	Ratio of Gold to Silver. Value.
	Gold.	Silver.				Gold.	Silver.		
1493–1520	162,400	1,316,000	8.1	10.75	1701–1720	256,400	7,112,000	27.7	15.21
1521–1544	171,840	2,164,800	12.6	11.25	1721–1740	381,600	8,624,000	22.6	15.08
1545–1560	136,160	4,985,600	36.6	11.30	1740–1760	492,200	10,662,900	21.7	14.75
1561–1580	136,800	5,990,000	43.8	11.50	1761–1780	414,100	13,054,800	31.5	14.73
1581–1600	147,600	8,378,000	56.8	11.80	1781–1800	355,800	17,581,200	49.4	15.09
1601–1620	170,400	8,458,000	49.6	12.25	1801–1810	177,780	8,941,500	50.3	15.61
1621–1640	166,000	7,872,000	47.4	14.00	1811–1820	114,450	5,407,700	47.2	15.51
1641–1660	175,400	7,326,000	41.8	14.50	1821–1830	142,160	4,605,600	32.4	15.80
1661–1680	185,200	6,740,000	36.4	15.00	1831–1840	202,890	5,964,500	29.4	15.75
1681–1700	215,300	6,838,000	31.8	14.97	1841–1850	547,590	7,804,150	14.3	15.83

GOLD PRODUCTION OF THE WORLD, 1851–1921

Year.	Value.	Year.	Value	Year.	Value.	Year.	Value.
1851....	$67,600,000	1871...	$107,000,000	1891 ..	$130,650,000	1911...	$464,346,495
1852....	132,800,000	1872...	99,600,000	1892...	146,292,600	1912...	474,322,664
1853....	155,500,000	1873...	96,200,000	1893...	158,437,551	1913...	462,669,558
1854....	127,500,000	1874...	90,800,000	1894...	182,509,283	1914...	439,078,260
1855....	135,100,000	1875...	97,500,000	1895...	198,995,741	1915...	470,466,200
1856....	147,600,000	1876 ..	103,700,000	1896...	211,242,081	1916...	454,176,500
1857....	133,300,000	1877...	114,000,000	1897...	237,833,984	1917...	419,422,000
1858....	124,700,000	1878...	119,000,000	1898...	287,327,833	1918...	380,924,000
1859....	124,900,000	1879...	109,000,000	1899...	311,505,947	1919...	365,166,000
1860....	119,300,000	1880...	106,600,000	1900...	258,829,703	1920...	335,000,000 [1]
1861....	113,800,000	1881...	103,102,000	1901...	260,877,429	1921...	327,000,000 [1]
1862....	107,800,000	1882...	102,000,000	1902...	298,812,493	.....	.....
1863....	107,000,000	1883...	95,400,000	1903...	329,475,401	.....	.....
1864....	113,000,000	1884...	101,700,000	1904...	349,088,293	.....	.....
1865....	120,200,000	1885...	108,400,000	1905...	378,411,754	.....	.....
1866....	121,000,000	1886...	106,000,000	1906...	405,551,022	.....	.....
1867....	104,000,000	1887...	105,775,000	1907...	416,101,396	.....	.....
1868....	109,700,000	1888...	110,197,000	1908...	443,355,856	.....	.....
1869....	106,200,000	1889 ..	123,489,000	1909...	458,424,058	.....	.....
1870....	106,900,000	1890...	118,848,700	1910...	453,766,523	.....	.....

Recent figures from the U. S. Bureau of the Mint. [1] Estimated.
[1] J. E. Caldwell & Co., Philadelphia, Pa.

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GOLD PRODUCTION OF THE WORLD, BY COUNTRIES.

	1918.	1919.	1920.	1921. (a)
Transvaal	$174,025,500	$172,230,400	$168,648,100	$167,701,000
Rhodesia	13,051,300	12,267,600	11,432,900	12,224,000
West Africa	6,803,000	6,102,800	4,336,800	4,960,000
Congo, Madagascar, etc	3,196,000	3,295,700	3,474,400	3,000,000
Total Africa	$197,394,700	$193,896,500	$187,922,200	$187,885,000
United States	$68,646,700	$60,333,400	$51,187,000	$48,094,000
Mexico	16,824,000	15,676,500	15,265,400	14,040,000
Canada	14,687,900	15,850,400	15,853,500	19,105,000
Total North America	$103,559,300	$91,860,300	$82,305,900	$81,239,000
Central America	$3,400,000	$3,300,000	$3,000,000	$2,500,000
South America	$12,795,000	$13,297,000	$12,246,000	$11,000,000
Russia, including Siberia	$12,000,000	$11,000,000	$1,447,000	$2,000,000
France	200,000	150,800	150,100	150,000
Other Europe	212,800	155,300	210,900	200,000
Total Europe	$12,712,800	$11,306,100	$1,808,000	$2,350,000
British India	$10,028,200	$10,486,000	$9,027,800	$8,090,000
British and Dutch E. Indies	2,571,400	3,010,000	2,817,500	3,000,000
Japan and Chosen	8,405,900	5,242,000	5,935,000	5,500,000
China and others	4,509,000	6,479,000	6,306,000	6,000,000
Total Asia, not inc. Siberia	$25,514,500	$25,217,000	$24,086,300	$22,590,000
Australasia	$29,268,600	$26,911,500	$23,649,000	$20,000,000
Total for world	$383,606,000	$365,788,400	$335,017,400	$327,564,000

(a) Preliminary estimates.

The table below, compiled by Samuel Montagu & Co. of London, shows the national holdings of gold at or near the end of 1921:

Country.	Date.	Amount.
British Empire		£246,787,545
United States of America:		
Treasury (a certain amount of gold certificates, against which gold is held in the Treasury total, is included in this total)	Nov. 2	215,099,000
Federal Reserve Banks	Nov. 2	574,530,000
Belgium (including silver), State Bank	Dec. 22	12,948,000
Denmark (including silver), State Bank	Nov. 30	12,594,000
France, State Bank	Dec. 29	219,155,000
Germany, State Bank	Dec. 23	48,668,000
Holland, State Bank	Dec. 19	50,138,000
Japan (including silver), State Bank	Nov. 19	129,129,000
Norway, State Bank	Dec. 22	8,124,000
Spain, State Bank	Dec. 24	99,638,000
Sweden, State Bank	Dec. 17	15,159,000
Switzerland, State Bank	Dec. 23	21,745,000

The returns for Austria, Hungary, Italy, and Roumania do not discriminate between gold and paper, and therefore are not included. By March, 1922, the United States held approximately $3,700,000,000 of gold, and the issuance of gold certificates was resumed, which means that a certain amount of gold would get into circulation once more.

Some idea of the "premium" on gold in England may be obtained from the following table, which also shows how the premium rises and falls with the corresponding movements in sterling exchange:

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1921.	Per Ounce of Fine Gold—Highest. s.	d.	Lowest. s.	d.	Average. s.	d.	Exchange. Dollars.
January	115	11	105	7	109	11.8	3.72
February	107	2	107	7	105	11.7	3.86
March	105	11	104	6	105	2.7	3.90
April	105	5	104	1	104	8.6	3.92
May	106	4	102	8	103	7.4	3.97
June	111	0	105	5	108	10.2	3.77
July	115	2	110	1	113	1.0	3.63
August	115	5	110	4	112	6.6	3.65
September	111	6	109	8	110	7.5	3.72
October	110	6	104	0	106	1.2	3.86
November	104	10	102	8	103	8.3	3.96
December	102	7	97	7	99	2.4	4.15
For 1921	115	11	97	7	107	0.5	3.84

The following movements of gold are from the Monthly Summary of foreign commerce of the United States, issued by the Department of Commerce:

Year.	Imports.	Exports.
1911	$57,445,184	$37,183,074
1912	66,548,772	47,424,842
1913	63,704,832	91,798,610
1914	57,387,741	222,616,156
1915	451,954,590	31,425,918
1916	685,990,234	155,792,927
1917	552,454,374	371,883,884
1918	62,042,748	41,069,818
1919	76,534,046	368,185,248
1920	417,068,273	322,091,208
1921	691,267,448	23,891,377

Of the imports, $202,091,349 came from Great Britain, $190,688,144 from France, $66,355,925 from Sweden, $32,009,553 from India, $17,912,687 from China, $19,926,761 from Germany, $19,893,019 from Holland, $16,970,261 from Australasia, and $11,941,685 from Colombia. Canada sent into this country a total of $36,856,110, all of which would command a premium, owing to the depreciated value of the Canadian dollar.

Of the exports, $9,621,655 went to Hongkong; $7,090,419 to Mexico, $2,913,783 to Canada, and $1,179,000 to India.

In discussing[1] the world's greatest gold movement, John Oakwood said that imports into the United States during 1921 exceeded all other records. The nearest approach to it was in 1916, when the total was $686,000,000, but the outflow in that year was $156,000,000, whereas in 1921 it was only $24,000,000. The outflow in 1921 was the smallest in 23 years. Mr. Oakwood proceeded to discuss where this gold came from and the effect on Europe, which sent nearly 80 per cent. of it. Some financiers view this huge stock of metal with concern, as it is draining Europe; while others look upon the gold with much satisfaction, demanding that it be held and used as the basis of cheap money and credit and business expansion.

Gold movements in Great Britain during 1921 amounted to £49,676,327 imports and £59,348,158 exports. The large excess of exports arises

[1] *Annalist*, Jan. 9, 1922.

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from the fact that gold entering was generally declared at coinage value and its exit was calculated at market value. The Transvaal sent £34,513,606 to London, the total output of that State. Rhodesia and West Africa sent £2,064,016 and £1,083,727, respectively; but Australia and New Zealand only sent £2675. Exports from England included £55,456,340 to the United States and £1,539,987 to India.

Silver

Regarding market conditions for silver the Annual Bullion Letter of Messrs. Samuel Montagu & Co. of London contained the following authentic and pertinent information:

On Jan. 3, the first working day of 1921, the price was quoted at 41¾d. for cash and 41⅞d. for two months' delivery, as compared with 40⅞d. and 41¼d., respectively, on the concluding day of 1920. Prices however did not continue long to advance. The price fixed for both deliveries on the 6th of January—42½d.—proved to be the highest point touched until the first nine months of the year had almost elapsed. After hovering round 40d. for some weeks, by Feb. 1 prices descended sharply to 34½d. for cash and 34d. for two months' delivery. About this date news reached London that a Philippine institution had had to close its doors, being oversold £2,000,000 in gold (in other words overbought that amount in silver), a liability which it was unable to meet.

A notable feature of this period was the growth of visible stocks in Shanghai, which, eight days before the Chinese New Year—Feb. 6—reached a total of 69,000,000 oz., including sycee, dollars, and bars. This accumulation represented previous purchases made in preparation for squaring debts on that auspicious occasion. It has not been uncommon for individuals, unable to comply with this laudable Chinese practice, to wipe out the ignominy by committing suicide.

The fall encouraged a more active demand from the Indian Bazaars, which had been more or less the mainstay of the market, and a measure of stability was assured. Demand did not come only to London, as China and San Francisco were drawn upon for considerable quantities.

On Feb. 7 the prohibition upon the export of silver bullion without a license was removed, but that upon foreign silver coin—freed in 1920—was again established; while the embargo upon other silver coin remained. The freeing of silver bullion made no material change in the market conditions, but it was a welcome saving of labor for exporters, inasmuch as the application for a license had become practically a formality—though an irksome one—and frequently a cause of delay when hasty shipment was required.

Demand from the Indian Bazaars failed to be maintained with vigor; one reason was the ease with which silver became available in the various silver centers, another the continued increase of visible stocks at Shanghai, temporarily eliminating competition from that quarter. The fall in the value of silver reacted upon the Indian Exchange, which, about the middle of February, approximated 1s. 4d., as compared with 1s. 6d. at which it stood at the beginning of the year.

A rapid fall in the value of silver continued until, on Mar. 5, the lowest quotations of the year were reached, namely 30⅝d. for cash and 30⅞d. for two months' delivery. These were the lowest rates reached since Nov. 11, 1918. On Mar. 5 the gold premium was about 23½ per cent. Adding that proportion to 25 11/16d.—the average value of

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silver during the five years before the war—the figures 31¾d. are obtained, showing that the price had actually dipped below its pre-war value.

SILVER PRODUCTION OF THE WORLD, 1856–1921

Year.	Kilograms.	Year.	Kilograms.	Year.	Kilograms.	Year.	Kilograms.
1856–1860	4,534,950	1888....	3,385,606	1900.....	5,599,216	1912.....	7,804,516
1861–1865	5,505,575	1889....	3,901,809	1901.....	5,438,443	1913.....	6,964,361
1866–1870	6,695,425	1890....	4,180,532	1902.....	5,121,469	1914.....	4,995,951
1871–1875	9,847,125	1891....	4,479,649	1903.....	5,386,044	1915.....	5,767,844
1876–1880	10,271,210	1892....	4,985,855	1904.....	5,669,124	1916.....	5,246,859
1881.....	2,592,639	1893....	5,339,746	1905.....	5,638,183	1917.....	5,417,972
1882.....	2,769,065	1894....	5,205,065	1906.....	5,683,947	1918.....	6,139,810
1883.....	2,746,123	1895....	5,667,691	1907.....	5,704,083	1919.....	5,488,000
1884.....	2,788,727	1896....	5,496,178	1908.....	6,612,304	1920.....	5,418,000
1885.....	2,993,805	1897....	5,663,304	1909.....	7,069,656	1921....	(e)5,250,000
1886.....	2,902,471	1898....	5,575,336	1910.....	7,471,663	.....	.....
1887.....	2,990,398	1899....	5,529,024	1911.....	7,906,446	.....	.....

(e) Estimated. 1 kilogram = 32.15 Troy ounces.

SILVER PRODUCTION OF THE WORLD, BY COUNTRIES
(In Troy Ounces, Fine Silver)

	1918.	1919.	1920.	1921.[1]
United States	67,810,100	56,682,400	55,361,500	62,700,000
Canada	21,284,600	16,020,600	12,793,500	13,135,000
Mexico	62,517,000	65,904,000	66,662,200	50,360,000
Central America	2,900,000	2,800,000	2,700,000	2,500,000
South America	15,561,000	14,750,000	13,763,200	14,000,000
Total America	170,072,700	156,157,000	151,680,400	142,695,000
British India	270,000	192,600	170,000	160,000
Burma	1,970,500	1,973,000	2,700,000	3,500,000
Japan and Chosen	6,626,400	4,975,400	5,237,000	5,000,000
China and others	97,900	92,000	103,000	100,000
Dutch East Indies	400,000	1,007,000	1,027,000	1,100,000
Total Asia	9,364,800	8,240,000	9,237,000	9,860,000
Transvaal	877,500	891,300	892,600	1,100,000
Rhodesia	175,700	180,500	164,000	150,000
Congo and other Africa	32,500	199,900	180,400	200,000
Total Africa	1,085,700	1,271,700	1,237,000	1,450,000
Spain and other Europe	6,871,700	3,600,000	4,989,000	5,000,000
Australasia	10,000,000	7,188,000	7,468,600	9,000,000
Total output in ounces	197,394,900	176,456,700	174,612,000	168,000,000
Total value in dollars	191,022,900	197,631,500	177,929,600	105,258,700
Average price in cents	96.772	1.12087	1.01940	62.654

Figures for foreign countries are based largely on the statistics collected by the United States Mint where no direct official figures can be obtained.
[1] Estimated.

A fortnight after the lowest quotation of the year, the stock in Shanghai reached so colossal an amount that a record was established. It was returned as about 46,200,000 oz. in sycee, 39,000,000 dollars, and 550 silver bars. The combined total is equal to about 77,250,000 oz. Still there is good reason why, apart from activity of trade, the stock in China should be larger than a decade or so ago. Then there were only five foreign banking institutions, now there are about twenty-five. The same reliance cannot now be placed upon the total of the stock as published, because it is not easy to be assured of the exactitude of individual returns derived from so many diverse sources.

A more or less steady flow of silver set in for India or China, sometimes at the same time for both, and prices remained fairly steady around 33d. for about a month, until

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specially keen inquiry from China upon an unwilling market suddenly carried quotations on Apr. 12 to 36½d. and 36d. for cash and two months' delivery, respectively. In the case of India, the demand was not on account of trade; the main cause was an exchange of the yellow metal for the white. In the case of China, civil strife was undermining public confidence, and silver stocks at the treaty ports had to be replenished, for material had to be sent to the Canton and other mints for coinage into dollars, which did not return coastward but disappeared into the interior. The Indian Bazaars declined for the time being to compete, and preferred to realize purchases already made, whereupon the market drifted into a somewhat lifeless condition, with the quotation a penny or so lower—about 35d.—during the next four weeks. The steadiness of the undertone was largely owing to the existence of considerable bear accounts, which, as contracts fell due, required the acquisition of cash silver, even though a fresh forward sale might be opened. Unless the future of silver be a very poor one, the value of cash silver has always considerable influence upon the general tone of the market.

Although silver prices began to tend downward, the Shanghai exchange kept remarkably steady. The official quotation remained from Apr. 19 to May 17 at 3s. 3d. the tael, after which it moved lower in sympathy with the value of silver. In the meantime the visible stocks in China shrank considerably, owing to heavy coinage by Chinese mints, and the need of fresh supplies kept China more or less in the market, though other demands remained scanty.

Some revival of demand from India set in toward the end of May, but, supplies from the Continent being more plentiful, the inquiry failed to lift the price appreciably, which indeed eased to 34⅛d. by the 30th of that month. The appreciation of the American dollar then began to render bears somewhat nervous, and encouraged the United States to hold back supplies for higher prices calculated in sterling. Quotations moved up to a 35d.—36d. level, and ruled thereabout until the middle of July.

AVERAGE PRICE OF SILVER IN NEW YORK
(In cents per fine ounce)

Year.		Year.		Year.		Year.		Year.	
1865.....	$1.337	1875...	$1.24	1885...	$1.07	1895...	$0.65	1905...	$0.604
1866.....	1.339	1876...	1.16	1886...	0.99	1896...	0.68	1906...	0.668
1867.....	1.330	1877...	1.20	1887...	0.98	1897...	0.60	1907...	0.653
1868.....	1.326	1878...	1.15	1888...	0.94	1898...	0.59	1908...	0.529
1869.....	1.325	1879...	1.12	1889...	0.94	1899...	0.60	1909...	0.515
1870.....	1.328	1880...	1.15	1890...	1.05	1900...	0.62	1910...	0.535
1871.....	1.325	1881...	1.13	1891...	0.99	1901...	0.60	1911...	0.533
1872.....	1.322	1882...	1.14	1892...	0.87	1902...	0.53	.....	.....
1873.....	1.297	1883...	1.11	1893...	0.78	1903...	0.54	.....	.....
1874.....	1.278	1884...	1.11	1894...	0.63	1904...	0.58	.....	.....

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1912.....	56.260	59.043	58.375	59.207	60.880	61.290	60.654	61.606	63.078	63.471	72.792	63.365	60.835
1913.....	62.938	61.646	57.870	59.490	60.361	58.990	58.721	59.293	60.640	60.793	58.995	57.760	57.791
1914.....	57.572	57.502	58.067	58.519	58.175	56.471	54.678	54.344	53.290	50.654	49.082	49.375	54.811
1915.....	48.855	48.477	50.241	50.250	49.915	49.034	47.519	47.163	48.680	49.385	51.714	54.971	49.684
1916.....	56.775	56.755	57.935	64.415	74.269	65.024	62.940	66.083	68.515	67.855	71.604	75.765	65.661
1917.....	75.630	77.585	73.861	73.875	74.745	76.971	79.010	85.407	100.740	87.332	85.891	85.960	81.417
1918.....	88.702	85.716	88.082	95.346	99.505	99.500	99.625	100.292	101.125	101.125	101.125	101.125	96.772
1919.....	101.125	101.125	101.125	101.125	107.135	110.430	106.394	111.370	114.540	119.192	127.924	131.976	111.122
1920.....	132 827	131.295	125.551	119.779	102.585	90.957	91.971	96.168	93.675	83.480	77.734	64.774	100.900
1921.....	65.950	59.233	56.023	59.337	59.810	58.510	60.260	61.597	66.160	70.970	68.234	65.760	62.654

Since May, 1920, American producers have been receiving $1 an oz., less about ½ ct., under the terms of the Pittman Act.

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AVERAGE PRICE OF BAR SILVER IN LONDON
(In pence per standard ounce, 925 fine)

Year.	Pence.	Year.	Pence.	Year.	Pence.	Year.	Pence.	Year.	Pence.	Year.	Pence.	Year.	Pence.
1845.	59.2500	1855	61.3125	1865	61.0625	1875	56.8750	1885	48.6250	1895	29.8750	1905	27.8390
1846.	59.3125	1856	61.3125	1866	61.1250	1876	52.7500	1886	45.3750	1896	30.7500	1906	30.8680
1847.	59.6875	1857	61.7500	1867	60.5625	1877	54.8125	1887	44.6250	1897	27.5625	1907	30.1880
1848.	59.5000	1858	61.3125	1868	60.5000	1878	52.5625	1888	42.8750	1898	26.4375	1908	24.4020
1849.	59.7500	1859	62.0625	1869	60.4375	1879	51.2500	1889	42.6875	1899	27.4375	1909	23.7060
1850.	60.0625	1860	61.6875	1870	60.5625	1880	52.2500	1890	47.6875	1900	28.2500	1910	24.670
1851.	61.0000	1861	60.8125	1871	60.5000	1881	51.6875	1891	45.0625	1901	27.1875		
1852.	60.5000	1862	61.4375	1872	60.3125	1882	51.6250	1892	39.8125	1902	24.0900		
1853.	61.5000	1863	61.3750	1873	59.2500	1883	50.5625	1893	35.6250	1903	24.7500		
1854.	61.5000	1864	61.3750	1874	58.3125	1884	50.6250	1894	28.9375	1904	26.3990		

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1911....	24.865	24.081	24.324	24.595	24.583	24.486	24.286	24.082	24.209	25.594	25.649	25.349	24.592
1912....	25.887	27.190	26.875	27.284	28.038	28.215	27.919	28.375	29.088	29.299	29.012	29.320	28.842
1913 ...	28.993	28.356	26.669	27.415	27.794	27.195	27.074	27.335	27.985	28.083	27.262	26.720	27.573
1914....	26.553	26.573	26.788	26.958	26.704	25.948	25.219	25.979	24.260	23.199	22.703	22.900	25.313
1915....	22.731	22.753	23.708	23.709	23.570	23.267	22.597	22.780	23.591	23.925	25.094	26.373	23.675
1916....	26.960	26.975	27.597	30.662	35.477	31.060	30.000	31.498	32.584	32.361	34.192	36.410	31.315
1917....	36.682	37.742	36.410	36.963	37.940	39.065	40.110	43.418	50.920	44.324	43.584	43.052	40.853
1918....	44.356	42.792	43.260	47.215	48.980	48.875	48.813	49.077	49.500	49.500	48.969	48.492	47.516
1919....	48.438	48.027	48.171	48.886	52.104	53.896	54.133	58.835	61.668	64.049	70.065	76.432	57.079
1920....	79.846	85.005	74.194	68.848	60.010	51.096	53.736	59.875	59.476	54.197	50.952	41.845	61.590
1921....	39.985	34.744	32.749	34.250	34.165	34.971	37.480	38.096	40.081	41.442	38.750	35.645	36.886

Meanwhile rumors became current that about a million kilograms (32,150,000 oz.) of German demonetized silver coin would come into the market. Bankers in several countries were approached, ostensibly to lend money on the specie, but really, so it was said, to hold the metal until the silver could be conveniently realized. As a consequence of the Government decision that silver bullion from this source brought to the United Kingdom on German account would be subject to 26 per cent. reparation duty, some of the silver in question was shipped to the United States and there pledged, the profits of marketing and refining the metal being therefore lost to England. It was astonishing how tranquilly the market regarded the possible sale of this large amount, and also the probability that the Royal Mint would have supplies to spare; for the reduction of the quality of the United Kingdom and other similar British coinage from 925 to 500 fine was bound to create a substantial surplus. If all the coins (£37,095.905 net value) issued since the commencement of the reign of King Edward VII alone, were re-minted, there would remain over no less than 57,330,035 fine ounces. Of course, what proportion of these and of the Victorian issues will find its way back can be but a matter of conjecture. An arrangement with the great Anglo-Eastern banks was made by which consignments of silver derived from such re-coinage were despatched from time to time for absorption in the East.

On July 28, competition by the Indians Bazaars with China carried the quotation up to 39½d. for cash and 38¼d. for two months. The large premium on cash delivery showed that the Indian demand was for a special settlement date on the other side. The price in India rose about this time to the very high figure of 105 rupees per 100 tolas. There was special reason at this time why the Bazaars were willing to pay so dearly for the metal, namely the good price obtainable for exported gold. In other words the ratio between gold and silver in India encouraged the people to take in silver and let out gold.

It is no new thing for Eastern peoples to establish a ratio between the two precious

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metals, quite irrespective of Government fixation of the gold or silver contents of the rupee. Inheriting sagacity derived from some thousand years of ancestral practice, the Indian people buy gold and sell silver or reverse the operation, relying upon the law of averages, and deciding on the right moment for exchanging one metal for the other by something which may be described as intuition, and rarely fail to evolve a profit in the long run.

The ratio between the value of silver and gold at different periods (calculated in sterling) is worthy of comparison. During the five years preceding the World War, the price of silver seemed to have stabilized in correspondence with normal conditions —that is to say, a favorable output and an ordinary demand both for currency and industry. Based on about 25 1/16d. per standard ounce, the average price for the years, and 77s. 10½d. per standard ounce of gold (coinage value), the ratio was 36.72 to 1. Based on 89½d. per standard ounce of silver (quoted on the 11th of February, 1920) which was the highest recorded price, and gold at 123s. per fine ounce (price on same day), the ratio is 15.25, approximating closely that adopted by the Latin Union. The lowest recorded price of silver—21 1/16d. (touched in November, 1902)—works out at 43.49, based on 77s. 10½d. per standard ounce of gold; while the lowest silver quotation since the war—30⅝d. on the 5th of March, 1921—equals 38.15 with gold quoted 105s. 3d. per fine ounce. On the 5th of February, 1920, gold reached its highest point—127s. 4d. the fine ounce; the ratio with silver at 86⅞d. per standard ounce (the price of that day) was 16.25.

The rupee value of gold exports, far exceeding on the whole those of silver imports, afforded a strong support to the Indian exchange, which, failing a good Indian export trade, would not have shown such resilience had not excellent supplies of gold been available during the major part of the year. When gold became more difficult to obtain during the later months, the Indian exchange began to show the lack of the stimulus to which we refer.

During the month of August the level of prices was rather lower—around 38d.— and business was largely speculative. The balance of trade now began to move in favor of India. This was attributable to gold exports, not trading transactions, Indian produce being difficult to sell abroad owing to the poor ability of Europe and America to buy, also to the vagaries of the Continental exchanges. Bullish speculative interest taken by the Indian Bazaars, as well as actual shipments to that quarter, created a good tendency during September. This was enhanced by bear covering and a sudden strong demand from China, which carried the cash quotation to 43⅜d. on the 27th of that month. Producers and holders of silver being slow to respond, prices would have been forced much higher, had not the pressure from China been relaxed as suddenly as it arose.

The market now became irregular; Chinese and Indian operators did not confine themselves to the one attitude of buyer or seller; frequently groups acted in opposition to each other, and both China and India would each buy and sell on the same date. The air became charged with speculative activity. America and the Continent entered into similar double operations with zest, and no reliance could be placed from day to day upon the tendency of the market.

Amid this uncertainty came a collapse in the value of the German mark, startling in its intensity and thoroughness. Chinese speculators veered round and bought sterling —that is, sold silver—and sharp movements ensued in China exchange. The necessity, however, for providing against unusual calls on stocks in China caused steady buying by the great Anglo-Chinese banks, which held the price fairly steady in the neighborhood of 40d. until the end of the first week in November.

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The danger in connection with Chinese stocks lay in the fact that the Chinese Government found itself unable to repay borrowed funds. It had counted upon help from the Consortium of the Powers, which, however, did not see its way to make a loan for the purpose.

The departure on Nov. 22 of the steamship *Egypt*, due to arrive in Shanghai in comfortable time for the New Year, which on this occasion fell on Jan. 28, 1922, synchronized with a fall in the price; whereupon a gradual descent took place until 34½d. was fixed for both deliveries on Dec. 8, the market being fairly well supplied from the Continent and elsewhere; direct Eastern inquiry was almost absent. Meanwhile bear covering was the main support.

Some recovery—not, however, substantial—ensued on the receipt of orders from the Indian Bazaars to buy for arrival in India at the January settlement. Though the amount was large, the cash quotation did not exceed 36⅜d.—so free were offerings from the Continent, America and China. The tone of the market continued dull until the end of the year. The closing quotations were 34⅝d. for cash and 34½d. for two months' delivery.

During the greater part of the year, silver for prompt delivery commanded a premium—not very substantial except in February, when 2d. was quoted on the 4th of that month.

The range of prices was less than during 1919 and 1920. It was almost exactly one quarter of that in 1920—12¾d. as against 50⅝d. The highest quotation during the year—43⅜d.—was less than half the remarkable highest record in 1920.

Movements of bar silver in the United Kingdom were as follows for the year 1921:

	Imports, Ounces.	Exports, Ounces.
Netherlands	8,135,814	2,431,082
Belgium	894,239	30,660
France	10,476,525	263,768
China (including Hongkong)	.....	19,685,334
United States of America	18,808,107	.....
Other American countries	397,868	187,033
Egypt	614	386,117
British India	4,986	38,721,561
Canada	5,235,113	457
Other countries	2,079,142	856,932
Total	46,032,408	62,562,944

In addition to the above imports, over £2,000,000 of Imperial and West African coin was imported and demonetized, thus becoming available for export as bullion.

A prosperous India spells more or less continuous demand for silver—the precious metal in which even the poorest peasant has delighted to invest his savings. The demand used to be met in two ways—by silver rupees or by manufactured silver articles, chiefly jewelry and utensils. A change, however, has come about owing to the extended use of rupee notes, which is ever increasing. Though much of this is a consequence of the World War, as in other countries it is also a sign that a great deal of the unrest in India is on the surface, for, were revolutionary elements likely to succeed, confidence in the Imperial note issue would certainly be jeopardized. The increasing circulation of notes does not suggest the likelihood of a dearth of silver coin, nor does the huge total held in the Treasury reserves encourage the idea that the mintage of rupees will be necessary for a long while to come.

Two recent currency innovations have been distinct successes. The people of India have taken kindly to nickel instead of silver fractions of the rupee. These coins—light and presentable—lessen the cost of providing the small change which is so vital a link in the daily business of great populations. The other reform, the issue of 1- and 2½-rupee notes (commonly styled little and big Gubs, after M. M. S.

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Gubbay, the Controller of Currency responsible for their origin) seems also to have been welcomed. The 1-rupee note, which at first favored city rather than country life, is now going farther afield, but the 2½-rupee note is not of so robust a habit; possibly a 2-rupee denomination would have been more popular.

Therefore, looking broadly at the probability of Indian absorption of silver in the near future, we cannot but come to the conclusion that the possibility of an absence of Indian coining will more than offset any increased demand for silver from the Indian Bazaars as a consequence of the solid improvement in material prosperity, which is, and may reasonably be expected to be, enjoyed by the Indian Empire.

The foreign trade of China—always showing a large favorable balance—has increased from 925,468,011 taels (2s. 8¾d. exchange rate) in 1914, to 1,303,881,530 taels (6s. 7½d. rate) in 1920.

Early in 1922 China had the anomaly of a threatened bankrupt Government coupled with exceptional internal prosperity. In 1921 its foreign trade exceeded all records, and there is reason to believe that, if the ills of misgovernment were removed, economic development is ripe for an advance on a great scale. The very distrust of the Government notes—and those of some other governments also (for the Chinese people have been badly hit by the collapse of the Russian ruble note)—has created a heavy demand for silver, especially during the latter part of the year. The lack of public funds that exists applies to those needed for carrying on the functions of Government—though not for the discharge of those Government obligations which are secured upon revenues administered under foreign control. A disturbing element has been the extreme speculation in exchange and silver which has prevailed amongst native dealers and banks and also among certain foreign banking institutions.

What then can be divined from the Chinese situation? Much depends upon the attitude of the Powers towards the Republican authorities. If a sound responsible Government could be provided for the Chinese people, and the collection and expenditure of its finances properly supervised—a consummation still seemingly far off—the inherent resources and the labor capacity of that country would suffice to give it a worthy place among the nations. A weak China renders it the prey of the unscrupulous—both within and without. There is reason to believe from the above and other causes that the future of China may be eventually brighter than it has ever been. There is room for hope that reforms of administration, finance, and currency may lie in the not far distant future. Finance and currency may then create a special demand for silver.

The sale of Chinese commodities, which during the war seemed mainly controlled by the difficulty of shipping, has recently languished owing to the inability of Europe to pay for goods, as well as to overstocked markets; otherwise the price of silver would have been much better maintained. Should improvement in world trade set in, many of the conditions prejudicial to Chinese export trade will ameliorate. This would favor silver imports and check the decline in silver prices—were it not for the possibility of visible stocks being swollen afresh by an outflow from the provinces of China—where silver has accumulated during the recent distrust of notes.

On the whole, taking into consideration the facts alluded to, the prospects of substantial support to the silver market coming from China are good.

A fair estimate of the world stocks of silver at the end of 1921 is as follows:

	Ounces.
London	4,000,000
Shanghai (including dollars)	50,000,000
India	4,000,000
On the sea (from London and from San Francisco)	9,800,000

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The world demand for coinage is not favorable to silver unless some unexpected step be taken in the direction of bimetallism. The tendency at present is in the direction of substituting base metals as a material for subsidiary coinage. Newly formed European States are sellers, not buyers, of the metal. The old silver mark, kroner, and mid-European coins are being hurried into the melting-pot. If silver ever does form a definite link in the chain of Continental currencies again, the time is a long way off, and the price of silver meanwhile will lack much of the support of days gone by. Nay more, until the surplus from the reduction in the quality of British silver coin is realized, together with the bullion derived from demonetized marks and other European currency, there will be a considerable source of supply additional to production.

The world's production of silver during 1921 is likely to be lower than in 1920, and our estimate is 165,000,000 oz.

The following tables of imports and exports of silver are from the Monthly Summary of foreign commerce of the United States, issued by the Department of Commerce at Washington.

SILVER MOVEMENTS

Imports.		Exports.	
Year.	Value.	Year.	Value.
1912	$48,401,086	1912	$71,961,755
1913	35,867,819	1913	62,776,631
1914	25,959,187	1914	51,603,060
1915	34,483,954	1915	53,598,884
1916	32,263,289	1916	70,595,037
1917	53,340,477	1917	84,130,876
1918	71,375,699	1918	252,846,464
1919	89,410,018	1919	239,021,051
1920	88,060,041	1920	113,616,214
1921	63,242,671	1921	51,575,399

Country.	Imports from			Exports to		
	1919.	1920.	1921.	1919.	1920.	1921.
France	$75,524	$117,508	$184,513	$6,588,197	$39,920	.....
Germany	.....	.....	5,320,337	.....	.....	.....
United Kingdom	61,746	925,520	1,199,408	15,635,386	4,924,778	$11,843,103
Canada	7,121,469	3,788,435	3,807,203	7,854,378	7,061,755	4,591,373
Central America	5,200,481	7,198,851	2,016,826	.....	4,009,710	284,843
Mexico	63,303,437	53,197,337	41,249,925	1,926,433	3,241,090	2,140,667
West Indies	90,467	209,444	306,510	162,789	1,656,507	424,972
Brasil	2,155	.....	.....	.....	2,333	.....
Chile	1,927,324	3,744,351	1,825,744	.....	.....	.....
Colombia	271,274	846,404	178,632	2,000	.....	239,500
Peru	8,862,537	11,990,677	5,598,218	.....	.....	.....
Venezuela	2,521	905	3,309	850,000	10,000	285,000
China	.....	.....	8,029	77,583,367	61,347,610	12,872,879
East Indies	1,773,584	2,671,555	494,047	.....	.....	.....
Argentina	.....	37,324	19,613	3,867	13,173	900
India	.....	.....	12,368	109,180,718	642,408	3,233,382
Hongkong	20,000	.....	396	10,245,351	24,872,571	10,408,021
Other countries	647,499	3,331,730	6,368,030	8,988,337	8,801,369	5,254,759
	$89,410,018	$88,060,041	$63,242,671	$239,021,051	$113,616,224	$51,575,399

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In their Annual Review of the silver market for 1921, Messrs. Handy and Harman of New York say:

Silver, which either influences or is itself affected by the movements of the Indian, Chinese, and English exchanges, has been one of a number of commodities that have afforded ample opportunity for speculative transactions.

The white metal, together with other commodities of worldwide usage, suffered a violent reaction from the days of artificial prices and delusive prosperity. Early in 1921, New York official quotations for bar silver reached pre-war levels of below 60 cts., and during the remainder of the year have never gone far above this figure. In addition to the prevalence of speculative transactions, perhaps the most salient feature of the market has been the situation with regard to silver coinage.

Many nations which used to buy millions of ounces a year of new silver for mintage have not only discontinued their purchases, but those of Central Europe have actually sold over 49,000,000 oz. of coin and melted coin silver in the London market during the last two years. Of this amount, some 23,000,000 oz. was shipped to England during 1921, and Germany alone has exported over 8,000,000 oz. to the United States since the first of April, due to the 26-per cent. reparation duty claimed by the British Government on the importation of silver.

In addition to the many European countries, both large and small, which have abandoned silver coinage, a number of nations, notably England, Holland, and the Scandinavian group, have already authorized debasement of their subsidiary coinage. This step so vitally affecting the silver market was actually begun by England in December, 1920, when shillings and other silver currency reduced in fineness from 925 to 500 were first issued.

A rough guess of 40 million ounces as to the amount likely to be added to the world's supplies from this source during the next year or so is not unreasonable. By Nov. 30, 6,500,000 oz. had actually been sold in London from this source. Other nations that have reduced the silver fineness of their currency may or may not have contributed to the year's stock of available bullion, but the fact remains that none of them is at present or is in the near future likely to be a consumer of silver for mintage purposes, as formerly the case. Furthermore, the vast issues of paper money by the debt-ridden nations of the Eastern hemisphere, in accordance with Gresham's law, soon drove silver currency out of circulation. As previously stated, quantities of marks, francs, crowns, lire, and other specie which had been hoarded, have already found their way to the melting-pot, but large amounts of these silver coins are still intact, and only the years to come can tell whether they will be reduced to bullion or will eventually return to circulation with the recovery of depreciated exchange values.

As contrasted with the lack of silver purchases by European Governments for mintage purposes, the activities of the United States Government in this direction are one of the market features. During the fiscal year ending June 30, 1921, the receipts of silver purchased totaled more than 66,000,000 oz., of which over 60,000,000 oz. was Pittman Act silver. It is interesting to note that the purchases of the fiscal year of 1921 exceeded even those of the record years following the purchases under the Acts of Feb. 28, 1878, and July 14, 1890.

From the latter part of May, 1920, through Dec. 30, 1921, silver bullion bought to replace that obtained by melting silver dollars under the Pittman Act of Apr. 23, 1918, approximated 88,500,000 oz.

Ever since the United States Treasury began to buy, for replacement of sales to the Indian Government, the domestic silver output at $1 per ounce 1000 fine, con-

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siderable criticism of this phase of the Pittman Act has appeared in the press. Explanations of the actual workings of the Act, emphasizing the fact that the Government's sales and purchases were both made at the same figure, and calling attention to the fairness of the legislation as well as to the moral necessity of living up to the original terms of agreement, have likewise received publicity. Rumors as to the possibility of the repeal of this Act, nevertheless, continue to circulate from time to time. At present, however, there is no pending legislation for its repeal, and the occasional inferential attacks which have been made on the floor of the Senate and House have, we understand, been answered to the apparent satisfaction of their sponsors.

While more silver was shipped to India during 1921 than in 1920, the heaviest part of the year's consumption has again been in China. India's requirements during the first three months proved to be of greater volume than was anticipated, but taken as a whole, her purchases have been intermittent, and largely dependent upon her ability to sell gold and the speculative position of individual traders.

The element of speculation has been even more in evidence with regard to China and Far Eastern Exchanges. Much of the year's business has been due to the adjustment of speculative positions, and at times China has posed as buyer and seller on the same day or on days not far apart. Nevertheless, that country has absorbed large quantities of silver, and with the exception of occasional periods of inactivity, has proved the backbone of the market. In view of the slack movement of goods from her ports, China's support is further proof of the inherent qualities of that great Republic for absorption of the white metal.

China's monetary system, with small silver coins of nominal value, dollars—both foreign and Chinese—and many kinds of taels of varying weight and fineness all used as mediums of exchange, has long been a great handicap to the development of the trade of that country. In this connection, therefore, it is a source of satisfaction to note that the Minister of Finances closed an agreement early in the year with a group of bankers regulating the terms of a three-year loan for the purpose of stabilizing Chinese money. The yield of this loan will be used to build a mint at Shanghai, which will not only be the first establishment of this kind possessed by China, but will also be one of the greatest in the world. It is stated that it will have a capacity of coining half a million dollars (Chinese) a day.

In spite of the fact that the speculative transactions in silver were unduly large during 1921, fluctuations appear relatively insignificant in comparison with the rapid advances of 1917–1919, and the violent reaction of 1920. If we regard the quotations of the first two months of 1921 with the year's low price of 52⅝ cts. on Mar. 5 as the culmination of the preceding decline, it may be said that, with the exception of the last three weeks in May, the market evidenced a steady upward trend until the 17th of October, when the year's high (73⅝ cts.) was reached. Following this advance, a moderate reaction occurred, and during the closing weeks of the year prices have fluctuated in the neighborhood of 65 cts.

Forecasts as to silver bullion prices for the near future are problematical, on account of the continuance of the large amount of speculative business which so confuses legitimate operations based on the underlying conditions of the market. Reports from India of a favorable monsoon and that country's return during the past year to a favorable balance of trade are not in themselves sufficient to warrant the assumption that India will soon again become the dominant factor in the silver situation.

Export trade, both in India and China, are so dependent on a return to more normal conditions in various countries throughout the world that the future silver

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requirements of these two countries are only to be found in the answers to a great many national and international problems as yet unsolved. The outcome of the silver coinage situation, to which we have previously alluded, will also influence the price of silver in a marked degree. But who is in a position to answer correctly this or any of the numerous other puzzling questions now attracting worldwide interest—so many of which are at least indirectly related to the future of silver?

Our estimate of the world's silver production during 1921 is 161,000,000 ounces.

The outlook for the price of silver was discussed[1] by C. C. Latour, who said that in the past the price of silver has been regarded by inter-

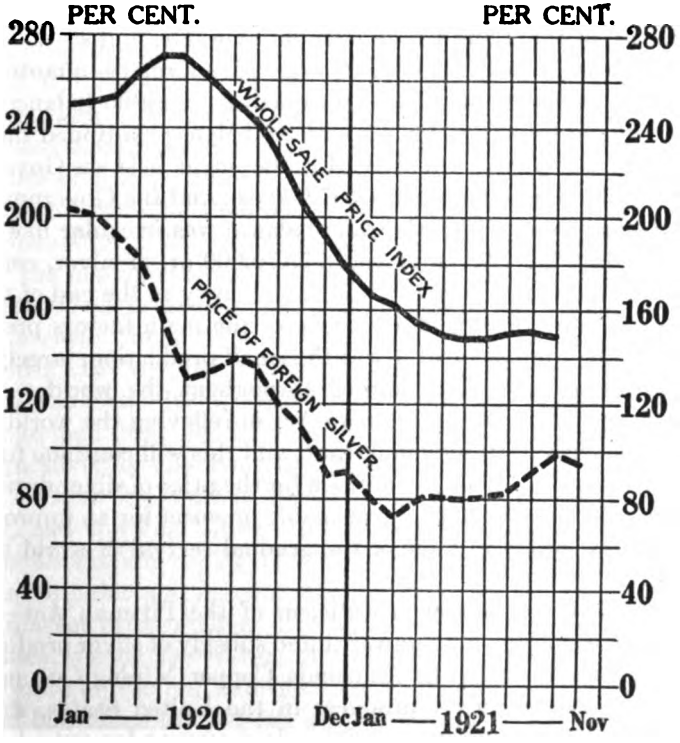

FIG. 1.—Price of silver as compared with wholesale price index, in per cent. of 1913 averages.

national bankers and traders as one of the most accurate and sensitive barometers of world business conditions, because over 600 million people use currencies based upon silver, and their purchasing power has a marked influence on world trade. There were three major movements in the price of foreign silver during 1921, namely (1) a generally downward

[1] *Annalist*, Jan. 9, 1922.

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trend in the early months of the year to 52⅝ cts. per ounce on Mar. 5, the lowest since 1914; (2) an upward movement from March to Oct. 17, when it was 73⅝ cts.; and (3) another downward movement to the close of the year, the price on Dec. 8 being 63¼ cts. The factors responsible were (1) the general movement of wholesale prices; (2) the demand in the Far East; (3) the demand in Europe and America; (4) the upward movement of British Exchange; (5) speculation; and (6) production. Being a commodity whose price is measured in terms of gold, the price of silver depends partly upon the movement of the business cycle, and to show this, Mr. Latour included the accompanying graph, which compares the price of silver with the wholesale price index. Early in 1921 the trade balances in India and China were unfavorable, and stocks of silver in Shanghai were nearly 62,000,000 oz., an enormous quantity. By mid-year and to September, India regained a favorable balance, which created a demand for silver, but an adverse balance continued thereafter to the end of the year. On Nov. 15, the silver held on Government account in India amounted to 271,597,000 oz., and the Government was not a buyer last year. China's trade balance was irregular like that of India. On Mar. 19, Shanghai held 77,170,000 oz. of silver, coincident with the low prices for the metal, but the quantity at the end of the year was down to about 45,000,000 oz. One of the main factors preventing a collapse of silver prices in 1921 was the small production, largely owing to curtailment of base-metal mining throughout the world. Another factor is the operation of the Pittman Act in relieving the world's silver markets of the current American output; and this will continue for about another three years. While the outlook for the price of silver during 1922 is uncertain, there seems to be a reasonable prospect for an improvement over present low prices in view of the gradual revival of world business conditions.

On account of the mistaken criticism of the Pittman Act—due to some persons considering it an unwarranted subsidy of silver production—C. F. Kelley,[1] president of the Anaconda Copper Mining Co., normally the largest by-product silver producer in the United States, discussed the issue at considerable length. In no instance, as far as had come to Mr. Kelley's attention, had the author of such criticism disclosed accurate information, if any were possessed, as to the conditions under which the statute was enacted, and the circumstances leading to it, although it constituted a measure of war legislation of the utmost importance. Mr. Kelley then discussed the nature and purpose of the Act, which is well known to all silver producers; the statistical situation; the enormous demand of Asia; the supply of the metal in the U. S. Treasury; how the

[1] *Min. & Met.*, No. 179, 5 (1921).

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Act was operated; the fact that there is no drain on the Treasury by this legislation; and the position of the American miner.

A real relationship exists between the famine in Northern China, which has a population of 90 millions, and the price of silver, according to T. T. Read.[1] If, as the result of the conditions existing early in 1921, the general buying power of China is much decreased, its support of the silver market will also be much less.

In discussing[2] silver mining during 1921, F. E. Wormser said that American silver producers were little concerned in the fluctuations of the silver market, as they received the fixed price of $1 an ounce, under the Pittman Act. Domestic silver consumption is becoming of increasing importance. The moving-picture film industry consumes about one-twelfth of it. It is unfortunate, in view of the attitude of European countries toward silver, that there are not other industrial channels of consumption equally promising. It is an anomaly that while the financial policies of Europe have dispensed with silver, the so-called "backward" nations have not diminished their regard for it.

Approximately 5,000,000 oz. of silver is used annually in the United States in the manufacture of photographic and moving-picture film. Of this, 4,500,000 oz. is used by the Eastman Kodak Co. The 61st meeting of the American Chemical Society was held at Rochester, N. Y., during April, and a visit was paid to the Eastman works. About 125,000,000 ft. of film was made during 1920. This material is coated with "dope" $\frac{1}{2000}$ of an inch thick, sensitized with silver nitrate. To make the silver salt, pure silver is dissolved in nitric acid, and evaporated to white crystals. These are washed and re-dissolved until all impurities are removed, and the final silver-nitrate crystals are placed on trays and stored in aluminium drying closets. When the nitrate is mixed with potassium bromide and gelatine, the sensitive "dope" is produced.

The market price of silver nitrate moves with the price of the metal; for instance, during December, the price of old or foreign silver was 67 cts. per ounce on the 7th, and the nitrate was 45⅞ cts., while on the 12th the metal had fallen to 64¼ cts. and the nitrate to 42⅝ cts.

Several books on silver were published during 1921, these including "Silver, Its Intimate Association with the Daily Life of Man," by Benjamin White, who is with the well-known London firm of bullion brokers, Samuel Montagu & Co.; and "From Silver to Steel" written by Roy Bridges for the Broken Hill Proprietary Co. of Broken Hill, New South Wales, whose principal business now is the manufacture of iron and steel at Newcastle in that State. The lead-silver-zinc mine is still being operated at Broken Hill. Its output of silver exceeds 174,000,000 oz. in

[1] *Min. Sci. Press*, **122**, 284 (1921).

[2] *Eng. Min. Jour.*, **113**, 85 (1922).

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35 years. In the first mentioned, silver is discussed as a commodity in three parts, namely, (1) mineralogy, mining, metallurgy, and marketing; (2) the silversmith's art at different periods; and (3) the utility of silver as money—past and present—with dissertations on Indian currency and Chinese monetary problems. Several instructive tables and charts are given. The book is quite non-technical in style.

A scholarly monograph on silver in Roman and earlier times was completed early in 1921 by William Gowland, professor emeritus of metallurgy in the Royal School of Mines, and communicated to the Society of Antiquaries of London. The essay is replete with facts and theories of historic interest. The first mention of silver as a metal, as far as can be ascertained at present, was in 4500 B. C. The discovery of silver arose, in all probability, as the result of the unpremeditated refining of lead-silver ore by the ancients; in fact, it is more than probable that these two metals were discovered at the same time.

Gold and Silver Mining in the United States

As will be seen from the accompanying tables, there was a decrease of over $2,000,000 in gold and about 5,000,000 oz. of silver when compared with the figures for 1920. On studying the production of the base metals for 1921, we find a decrease of about 60 per cent. in copper, 20 per cent. in lead, and 60 per cent. in zinc; and as these metals yield approximately 10 per cent. of the gold and 70 per cent. of the silver, it might be said that they were responsible for a large part of the falling-off in the precious metals. The balance will then have to be accounted for by general conditions, and as the Tonopah district was partly shut down for over three months by a strike, the deficiency in the silver output is practically accounted for.

A sidelight on the status of the reduction mills in the Western States was revealed in Serials 2287 A to G published by the U. S. Bureau of Mines, which consisted of a tabulation of all the plants—operating and idle. For instance, in California in 1920 there were 138 active plants having a daily capacity of 15,000 tons, but there were 320 idle plants of 17,000 tons capacity.

The preceding pages show the condition of the industry in this country, and the following notes tell what happened during 1921 and what may be expected in 1922 in the various districts. Acknowledgment for preliminary production figures and for some of the notes should be made to the U. S. Geological Survey.

The following tables show the United States production of precious metals from 1883 to 1921, inclusive:

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GOLD

Year.	Ounces.	Value.	Year.	Ounces.	Value.	Year.	Ounces.	Value.
1883	1,451,250	$30,000,000	1896	2,568,132	$53,088,000	1909	4,821,701	$99,673,400
1884	1,489,950	30,800,000	1897	2,774,935	57,363,000	1910	4,657,018	96,269,100
1885	1,538,373	31,801,000	1898	3,118,398	64,463,000	1911	4,687,053	96,890,000
1886	1,686,788	34,869,000	1899	3,437,210	71,053,400	1912	4,520,717	93,451,500
1887	1,603,049	33,136,000	1900	3,829,897	79,191,000	1913	4,299,783	88,884,400
1888	1,604,478	33,167,500	1901	3,805,500	78,666,700	1914	4,572,976	94,531,800
1889	1,594,775	32,967,000	1902	3,870,000	80,000,000	1915	4,887,602	101,035,700
1890	1,588,877	32,845,000	1903	3,560,000	73,591,700	1916	4,479,051	92,590,300
1891	1,604,840	33,175,000	1904	3,892,480	80,464,700	1917	4,051,440	83,750,700
1892	1,597,098	33,015,000	1905	4,265,742	88,180,700	1918	3,320,784	68,646,700
1893	1,739,323	35,955,000	1906	4,565,333	94,373,800	1919	2,918,622	60,333,400
1894	1,910,813	39,500,000	1907	4,374,827	90,435,700	1920	2,476,166	51,186,900
1895	2,254,760	46,610,000	1908	4,574,340	94,560,000	1921	2,375,479	49,105,500[1]

[1] Preliminary estimate.

SILVER

Year.	Ounces.	Commercial Value.	Year.	Ounces.	Commercial Value.	Year.	Ounces.	Commercial Value.
1883	35,732,800	$39,618,400	1896	58,834,800	$39,654,600	1909	54,721,500	$28,455,200
1884	37,743,800	41,921,300	1897	53,860,000	32,316,000	1910	57,137,900	30,854,500
1885	39,909,400	42,503,500	1898	54,438,000	32,118,400	1911	60,399,400	32,615,700
1886	39,694,000	39,482,400	1899	54,764,500	32,858,700	1912	63,766,800	39,197,500
1887	41,721,600	40,887,200	1900	57,647,000	35,741,100	1913	66,801,500	40,348,100
1888	45,792,700	43,045,100	1901	55,214,000	33,128,400	1914	72,455,100	40,067,700
1889	50,094,500	46,838,400	1902	55,500,000	29,415,000	1915	74,961,075	37,397,300
1890	54,516,300	57,242,100	1903	54,300,000	29,322,000	1916	74,414,800	48,953,000
1891	58,330,000	57,630,000	1904	57,682,800	33,456,000	1917	71,740,400	59,078,100
1892	63,500,000	55,562,500	1905	56,101,600	34,222,000	1918	67,810,139	66,485,129
1893	60,000,000	46,800,000	1906	56,517,900	38,256,400	1919	56,682,445	63,533,652
1894	49,500,000	31,422,100	1907	56,514,700	37,299,700	1920	55,361,573	60,801,955
1895	55,727,000	36,445,500	1908	52,440,800	28,050,600	1921	50,364,389	50,364,389[1]

[1] Preliminary estimate.

PRODUCTION OF GOLD IN THE UNITED STATES, BY STATES (*a*)

States.	1918.		1919.		1920.		1921.	
	Fine Ounces.	Value. (*b*)	Fine Ounces.	Value. (*b*)	Fine Ounces.	Value. (*b*)	Fine Ounces.	Value. (*b*)
Alabama	36	$700	.....	.....	10	$200	5	$100
Alaska	440,622	9,108,500	481,984	$9,963,500	412,915	8,535,700	362,633	7,496,300
Arizona	278,647	5,760,200	222,965	4,609,100	240,032	4,961,900	156,038	3,225,600
California	842,389	17,207,000	841,638	17,398,200	716,477	14,810,900	739,214	15,280,900
Colorado	621,791	12,853,500	495,810	10,249,300	363,218	7,508,400	331,354	6,849,700
Georgia	169	3,500	34	700	34	700	39	800
Idaho	30,764	636,000	34,085	704,600	22,668	468,600	25,315	523,300
Maine	.....	.....	10	200	(*c*) 10	200	10	200
Missouri	10	200	14	300	14	300	10	200
Montana	153,375	3,170,600	116,918	2,416,900	91,802	1,897,700	80,835	1,671,000
Nevada	322,276	6,662,000	225,384	4,659,100	175,451	3,626,900	155,472	3,213,900
New Mexico	30,871	638,200	28,319	585,400	21,720	449,000	10,981	227,000
North Carolina	38	800	5	100	54	1,100	73	1,500
Oregon	60,951	1,260,000	53,029	1,096,200	49,714	1,027,700	40,079	828,500
South Carolina	.....	.....	5	100	14	300	.....	.....
South Dakota	328,305	6,786,700	255,889	5,289,700	209,842	4,337,800	315,981	6,531,900
Tennessee	263	5,400	271	5,600	285	5,900	251	5,200
Texas	5	100	19	400	5	100	68	1,400
Utah	152,018	3,142,500	109,661	2,266,900	102,975	2,128,700	89,184	1,843,600
Vermont	47	800	19	400	.....	.....	.....	.....
Virginia	20	400	.....	.....	.....	.....	24	500
Washington	16,556	342,300	11,436	236,400	7,160	148,000	8,436	174,400
Wyoming	18	400	14	300	10	200	10	200
Total	3,269,171	$67,579,800	2,877,509	$59,483,400	2,414,410	$49,910,300	2,316,012	$47,876,200
Porto Rico	.....	.....	.....	.....	.....	.....	.....	.....
Philippine Islands	44,202	913,700	41,119	850,000	61,756	1,276,600	59,467	1,229,300
Total	3,313,373	$68,493,500	2,918,628	$60,333,400	2,476,166	$51,186,900	2,375,479	$49,105,500

(*a*) The statistics in this table are reported by the Director of the Mint, those for 1921 being the preliminary figures. (*b*) At $20.67 per oz. (*c*) Massachusetts.

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SILVER PRODUCTION OF THE UNITED STATES, BY STATES (a)

	1919.		1920.		1921.	
	Fine Ounces.	Value. (b)	Fine Ounces.	Value. (c)	Fine Ounces.	Value. (d)
Alabama	.....	.....	5	$5	4	$4
Alaska	690,151	$773,790	822,410	903,228	775,885	775,885
Arizona	5,702,911	6,392,222	5,431,637	5,965,404	2,864,962	2,864,962
California	1,153,614	1,293,051	1,654,653	1,817,256	3,460,219	3,460,219
Colorado	5,966,606	6,687,790	5,166,873	5,674,622	5,408,273	5,408,273
Georgia	8	9	.....	.....	3	3
Idaho	5,933,076	6,650,207	7,364,735	8,088,523	6,716,892	6,716,892
Illinois	6,000	6,725	8,625	9,473	1,800	1,800
Maine	4,142	4,643	.....	.....	3	3
Maryland	.....	.....	.....	.....	.....	.....
Massachusetts	.....	.....	1,160	1,274	.....	.....
Michigan	425,610	477,054	511,664	561,945	304,616	304,616
Missouri	75,991	85,176	123,094	135,190	62,000	62,000
Montana	15,012,258	16,826,790	13,263,356	14,566,746	9,168,011	9,168,011
Nevada	7,095,395	7,896,972	7,481,866	8,217,109	6,719,455	6,719,455
New Hampshire	.....	.....	.....	.....	.....	.....
New Mexico	851,821	954,781	699,745	768,509	625,334	625,334
North Carolina	19	21	10	11	12	12
Oklahoma	.....	.....	.....	.....	.....	.....
Oregon	236,620	265,220	101,658	111,648	55,713	55,713
Pennsylvania	.....	.....	90	99	.....	.....
Philippine Islands	15,715	17,614	22,118	24,292	34,429	34,429
Porto Rico	.....	.....	.....	.....	.....	.....
South Carolina	2	2	1	1	.....	.....
South Dakota	122,068	136,822	87,623	96,234	112,880	112,880
Tennessee	97,554	109,345	107,250	117,790	134,549	134,549
Texas	539,483	604,690	522,818	574,195	544,337	544,337
Utah	12,542,623	14,058,650	11,755,411	12,910,615	13,233,658	13,233,658
Vermont	2,200	2,466	.....	.....	.....	.....
Virginia	8	9	.....	.....	7	7
Washington	258,270	289,487	177,758	195,226	141,244	141,244
Wyoming	300	336	56,959	62,556	103	103
Total	56,682,445	$63,533,652	55,361,573	$60,801,955	50,364,389	$50,364,389

(a) Figures of the Bureau of the Mint and the U. S. Geological Survey, those for 1921 being a preliminary estimate. (b) At $1.121 per oz. (c) At $1.098 per oz. (d) At $1 per oz.

In published[1] replies to an interrogatory on metal-mining conditions throughout the United States, there were seven questions under silver, and there was a general affirmative reply that silver mining was recovering by reason of the lowering of costs; that the Pittman Act was sufficient incentive toward increased interest in the prospecting for and development of new silver properties; and that managers are considering the best means of reducing costs by installing more economical equipment, especially in underground loading devices. When asked whether the present lull in copper production was stimulating the operation of silver mines by reason of the cessation of output of by-product silver, the reply was in the negative.

Alaska.—The dominant features of the past year's operations, according to Alfred H. Brooks, were the closing of the Perseverance lode mine at Juneau; continuation of activity in quartz prospecting in the Sitka, Juneau, Salmon River, and Willow Creek districts; and a revival of placer mining. The most important event of the year to the future of

[1] *Min. Sci. Press*, 123, 544 (1921).

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the mining industry was the practical completion of the Alaska Railroad (official name for the Government line). There only remains the bridge at Riley Creek to be built this winter (1921–22) to give a train service from Seward to Fairbanks, except for the transfer across Tanana River at Nenana. The building of roads in Alaska was expedited during the year, so far as the funds available permitted. There is good reason to believe that the ocean transport service to Alaska is soon to be improved. These betterments of means of communication are the most valuable local factors in promoting a revival of Alaska mining.

There was another falling-off in production, as will be seen from the subjoined table:

Year.	Gold.		Silver.	
	Ounces.	Value.	Ounces.	Value.
1906	1,066,030	$ 22,036,794	203,500	$ 136,345
1907	936,043	19,349,743	149,784	98,857
1908	933,290	19,292,818	135,672	71,906
1909	987,417	20,411,716	147,950	76,934
1910	780,131	16,126,749	157,850	85,239
1911	815,276	16,853,256	460,231	243,923
1912	829,435	17,145,951	515,186	316,839
1913	755,947	15,626,813	362,563	218,988
1914	762,596	15,764,259	394,805	218,327
1915	807,966	16,702,144	1,071,782	543,393
1916	780,037	16,124,800	1,266,317	833,000
1917	733,911	15,171,300	1,351,100	1,099,800
1918	455,920	9,424,700	802,743	787,057
1919	481,984	9,963,500	690,151	773,790
1920	412,915	8,535,700	822,410	903,228
1921[1]	362,633	7,496,300	775,885	775,885

[1] Preliminary estimate.

To the end of 1921, Alaska had produced $328,000,000 of gold, of which $222,000,000 came from placers, dredges recovering $23,000,000 since 1903.

There was a small increase in the amount of placer gold recovered in 1921, the total being $4,090,000. There were a number of new finds, but they were in known fields of alluvium. The most promising of these discoveries was on Wilbur Creek, a tributary of Tolovana River, about 7 miles due east of Livengood Creek. The finding of coarse gold on this creek indicates that there may be a second belt of mineralization in the Tolovana area. Another deposit of placer gold was found on Kokomo Creek, a southerly tributary of Chatanika River, 10 miles east of Cleary. This discovery is significant chiefly because it indicates an eastern extension of the auriferous area. The Kuskokwim region reported an increase of $250,000 during the year.

Twenty-two dredges operated during 1921, saving over $1,500,000,

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an increase of 25 per cent. over 1920. Concerning gold dredging Mr. Brooks had the following to say:

The average gold recovery by dredging in the Yukon and Kuskokwim districts in 1920 was 96 cts. to the cubic yard, while that of Seward Peninsula was only 48 cts. This difference alone will account for the search for dredging ground being directed largely to inland Alaska, where the richest dredging placers have been developed. The Kuskokwim basin has been especially investigated for dredging placers, but during 1921 considerable attention has been given to the development of dredge mining in the Fairbanks, Rampart, and other Yukon districts. The facilities for communication provided for inland Alaska by the completion of the Government railroad and the increase of wagon-roads will give further impetus to dredge mining. Within the zone of its economic use the Nenana coal should also stimulate dredging. Cold-water thawing, now being so successfully used by many widely distributed Alaska dredges, greatly reduces fuel consumption, and is thus an important element in economical operation. The Seward Peninsula dredges are now working under the enormous handicap of the high cost of fuel. In 1921 the cost of coal at Nome was $35 a ton, and that of coal delivered at the placer mines was probably on an average at least $50 a ton. In comparison with this, many of the inland dredges are paying from $8 to $15 a cord for wood. No doubt an increase of business and the completion of the harbor for scows will lower the cost of freight at Nome and, together with the building of a wagon-road, will decrease the cost of land transportation. Another project to lower dredging costs on Seward Peninsula is to make available certain water-powers. The operators on Seward Peninsula will, however, always be hampered by the fact that the first steamers in summer do not arrive until at least a month after the dredging season opens. Eventually this situation will be somewhat relieved by an automobile road giving communication with the Government railroad. In spite of the present handicaps, dredge mining will increase on Seward Peninsula. It is to be expected that the advances will be made by large companies operating many dredges, with power furnished by central stations run by hydro-electric power or fuel. An experienced operator estimates the operating cost of dredging on Seward Peninsula, with cold-water thawing, as low as 18 cts. a yard, even under present adverse conditions. There can be no question of a large expansion of the present gold-dredging industry of Alaska.

According to E. E. Pearce,[1] in his paper "Cold-water Thawing of Gravel," a new method only costs 1.4 cts. per cubic yard against 9.5 cts. with the older cold-water process.

Gold lodes in Alaska have yielded $100,000,000 since the beginning, and of this, $80,000,000 came from the low-grade mines near Juneau. The Perseverance mine (Alaska Gold Mines Co.) was shut down for good on June 1.

During 1921 the Alaska Juneau mined 1,613,000 tons of ore averaging 85.41 cts. per ton. Of this, 43.96 per cent. was sorted out as waste. The mill recovered 59.97 cts. per ton by amalgamation, while the lead-silver concentrates were worth 1.8 cts. per ton net, making a total recovery of 61.77 cts. per ton mined. Costs are as follows:

[1] *Min. Sci. Press*, **124**, 154 (1922).

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Year.	Ore from Mine to Mill, Tons Daily.	Cost from Ore in Place to Mill Ore-bin, Cents per Ton.	Milling, Including Sorting, Cents per Ton.
1917 (new mill).....	2,356	62.95	71.71
1918.....	1,617	44.84	67.62
1919.....	1,898	42.97	56.08
1920.....	2,583	20.76	44.63
1921.....	4,482	19.97	35.54

Remodeling of the mill had not been completed by April, 1922, but a daily tonnage of 8000 is aimed at, with a milling cost of 20 cts.

Important advances were made in prospecting gold- and silver-bearing lodes of the Salmon River district, in the Portland Canal region, adjacent to the British Columbian boundary. Some small shipments of ore were made from this district. A little gold-quartz mining was carried on in the Valdez district of Prince William Sound and in the Hope district of Kenai Peninsula.

The Willow Creek district, tributary to Anchorage, produced about $100,000 of lode gold. This came from seven small mines, many of which are equipped with mills more remarkable for their novelty than for their efficiency. The lodes of the district occur in well-defined fissures traversing dioritic rocks. Most of these veins are remarkably persistent, though some are faulted. Within these lodes are rich ore-shoots, and mining has been limited to the search for and extraction of the rich ore from these shoots. In general the lodes have not been systematically developed to block out an ore tonnage, owing to lack of technical knowledge and of sufficient capital for the work undertaken. As a consequence most of the mines are being worked on a hand-to-mouth basis. Plans have been formulated for larger-scale operations and above all for more systematic exploration of orebodies. The surface indications more than warrant the careful underground exploration of the lodes already discovered.

Quartz mining at Fairbanks is still limited to the prospecting of some small lodes relatively rich in gold. Incidentally to this work some gold ore taken from five or six different properties was mined and milled. Between $30,000 and $40,000 worth of gold was recovered from these operations. The largest developments were on the Smith & McGlone property.

The Alaska Treadwell company continued systematic exploration of its gold lode mines in the Nixon Fork basin of the upper Kuskokwim region. In connection with this development work, some ore carrying gold, silver, and copper was mined and shipped by river and ocean boats. The outlook has been found sufficiently encouraging to justify the installation of a small reduction plant, which is now under way.

The Kantishna district, north of Mt. McKinley, and partly within a few miles of the new railway, was discussed by J. A. Haney.[1]

[1] *Min. Sci. Press*, **122**, 881 (1921).

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Arizona.—The decline in precious-metal output may be attributed mostly to the suspension of operations at many copper mines. The United Eastern mine produced about 60 per cent. of the State's gold.

Year.	Gold.		Silver.	
	Ounces.	Value.	Ounces.	Value.
1914	221,020	$4,568,900	4,439,500	$2,455,000
1915	220,392	4,555,900	5,665,672	2,826,500
1916	197,989	4,092,800	6,580,252	4,394,600
1917	267,700	5,533,800	6,962,257	5,754,700
1918	270,078	5,583,000	6,831,465	6,831,465
1919	222,965	4,609,100	5,702,911	6,392,222
1920	240,032	4,961,900	5,431,637	5,965,404
1921[1]	156,038	3,225,600	2,864,962	2,864,962

[1] Preliminary estimate.

"Oatman Today" was the title of a general article[1] on that district of Mohave County by W. F. Boericke. The camp is mainly supported by the Tom Reed and United Eastern mines, which are employing about 200 men. A number of other companies are prospecting—some by diamond-drill at a cost of $3.50 per foot. Recent developments in the Oatman United have been very encouraging. These are on the Hammond vein which parallels the Tom Reed vein, the main lode of the district.

For the full development of the district it is essential that costs be reduced, as there is a large tonnage of low-grade ore awaiting treatment—for instance at the Gold Road mine. There is considerable local optimism, and Oatman is expected to see much activity at an early date.

Early in 1922 the Tom Reed company arranged with the United American and Telluride companies to treat 50 tons of ore daily from each at a cost of $2 per ton.

The Octave gold mine, in Yavapai County, midway between Phoenix and Prescott, idle since 1905, previous to when it produced $2,500,000, is being reopened, according to J. N. Nevius.[2] The vein was mined for nearly 2000 ft. on the dip, and was strong at the bottom, but of low value, while a fault to the east cut it off. The Octave Mines Co. of Boston and Philadelphia is the new owner. The vein was recovered beyond the fault, and reserves are estimated at 40,000 tons of $14 ore. Tests show that a 96-per cent. recovery can be made by a simple process.

California.—Apart from South Dakota and Idaho, California was the only State recording a gain in gold and silver. While gold only increased by 3 per cent., silver more than doubled itself, due to the 1,200,000 oz. produced by the California Rand mine. The cessation of base-metal mining in this State is not reflected greatly in precious-metal statistics.

[1] *Eng. Min. Jour.*, **113**, 51 (1922).
[2] *Min. Sci. Press*, **123**, 122 (1921).

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The past 15 years' records show the following output:

Year.	Gold, Value.	Silver, Oz.	Year.	Gold, Value.	Silver, Oz.
1907.....	$16,727,928	1,138,858	1915.....	$22,442,296	1,678,756
1908.....	18,761,559	1,647,278	1916.....	21,980,400	1,936,910
1909.....	20,237,870	2,098,253	1917.....	20,087,504	1,989,800
1910.....	19,715,440	1,840,085	1918.....	16,784,400	1,432,812
1911.....	19,738,908	1,270,445	1919.....	17,398,200	1,153,614
1912.....	19,713,478	1,300,136	1920.....	14,810,900	1,654,653
1913.....	20,406,958	1,378,399	1921[1].....	15,280,900	3,460,219
1914.....	20,653,496	1,471,859			

[1] Preliminary estimate.

The statement by James M. Hill included the following:

The mines that produce mainly gold or silver were active throughout 1921, and numerous mines were reopened during the year. The signs of revival were evident in the spring, and by midsummer there were almost daily rumors of gold mines either being reopened or under development.

For a time in July it looked as if the mines along the Mother Lode, particularly those near Nevada City and Grass Valley, which are among the largest-producing deep mines in the State, might be forced to close because of the labor troubles. These disputes, however, were finally adjusted, and a wage-scale was established to hold until June 30, 1922. This scale, $4.25 a day for machine-men and $3.75 for shovelers, has been more or less generally adopted throughout the State.

In Amador County, the Kennedy and Argonaut mines resumed production after a successful fight against fire and water that tied them up for months. By February, 1922, the Argonaut with 40 stamps was at full capacity, and 40 of the 100 stamps at the Kennedy were dropping. The Plymouth and Central Eureka mines developed good ore in the lower levels. The Moore mine, at Jackson, was reopened after an idleness of 20 years. In Calaveras County the Morgan mine has developed a large quantity of ore, and the 30-stamp mill was in continuous operation. A fire at the Sultana mine, at Angels, destroyed all the surface equipment. Several of the mines at French Camp, Murphys, Melones, Mokelumne Hill, and West Point were reopened during 1921. In Eldorado County the Havilah mine, at Nashville, was a steady producer, as was the Golden Unit at Placerville. The Grit mine, at Georgetown, and the Rising Sun, at Colfax, Placer County, were added to the list of producers during the year.

Nevada County, which contains the Empire, North Star, and Idaho-Maryland, all producing mines, was about as active as any of the mining counties of the State. The Allison Ranch mine, however, was closed down; but the Alcalde, Bullion, Union Jack, and Norambagua were reopened.

The Belmont-Shawmut, at Shawmut, Tuolumne County, was a steady producer, and the Eagle Shawmut and Magenta, at Jamestown, were reopened, as was the Rawhide, at Rawhide, and the Patterson, at Sonora.

The once famous Princeton, Pine Tree, and Josephine mines, in the Mariposa Grant, Mariposa County, were bonded to strong companies and will soon be producing.

There was some development in western Kern County, though naturally the greatest interest there is centered about the silver mines near Randsburg. The revival of this camp was spectacular and included many of the gold mines, among them the Yellow Aster, in which several sets of lessees have been working throughout the year.

San Bernardino County and the other desert counties were hard hit, for their mines produce mostly copper-lead-zinc ores, for which there was almost no market. The operations at Darwin closed very suddenly about midsummer, but the Cerro Gordo, Santa Rosa, Slate Range, and Estelle shipped some ore.

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On the whole the outlook is encouraging, for if only a small number of the many enterprises started near the end of 1921 mature, the year 1922 will witness much more mining activity throughout the State than has been known for some time.

In discussing mining on the Mother Lode of California, A. E. Rau Roesler[1] considers that the high cost of supplies is responsible for there being so few gold producers in that region today. It has also suffered greatly from lack of development capital and the shortsightedness of operators. Large sums are needed for exploration, to pass through the barren zones and keep development ahead 500 ft. in depth. The potential qualifications of the Lode cannot be duplicated in any other gold-mining country, and a vast and profitable field is offered for constructive geological and metallurgical work.

On the other hand, it may be mentioned here that after spending about $1,000,000 in reopening, equipping, and doing extensive work in the Old Eureka mine at Sutter Creek, the mine was closed for good at mid-1921, because the expected ore was not found. Work was resumed in 1914, and continued throughout the war period with commendable zeal, but beyond opening some medium-grade ore, results were not worthwhile. Before being closed in the eighties, the yield was approximately $20,000,000.

Discovery of rich silver ore in the Randsburg district, San Bernardino County, southern California, was mentioned in the last volume of MINERAL INDUSTRY, and during 1921 several interesting articles were published concerning this deposit, known as the Kelly mine of the California Rand Silver Co. The series of articles[2] by A. B. Parsons was both descriptive and technical. The third article, on treatment of the ore, will be found in the metallurgical section of this chapter. Events moved rapidly at this mine. It was a rich prospect in April, 1919; the first dividend was paid in September of that year; the output to December, 1921, was 30,130 tons of ore, worth $2,878,946 gross, and $127,061 gold and $2,101,394 silver, net; over $1,000,000 in dividends has been paid, and a 150-ton mill is now at work. The new mine is advantageously situated, having an electric transmission line within half a mile, a water pipeline passes over the property, and the Santa Fe Railroad is only three-quarters of a mile distant. About 100,000 tons of $20 ore has been developed above the ninth level.

Under the title of "A Sagebrush Silver Producer," Jay A. Carpenter[3] also described the Kelly mine at Randsburg, mostly from a geologic standpoint.

[1] *Min. Sci. Press*, **122**, 807 (1921).
[2] *Min. Sci. Press*, **123**, 667, 855 (1921); **124**, 11 (1922).
[3] *Eng. Min. Jour.*, **112**, 132 (1921).

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The Randsburg district now has 35 shafts being worked, and 500 men are employed. The Yellow Aster mine is again in operation.

G. J. Young[1] covered gold mining at Carson Hill, Tuolumne County, where the Carson Hill Gold Mining Co. of Boston has been meeting with such success under the direction of W. J. Loring. The most important development is in the old Morgan mine, which was acquired in 1918, and extraction is now at the rate of 180,000 tons per annum, and a large reserve of ore is available. The whole property has been fully equipped, and everything is electrically driven. Underground work in 1920 cost $3.13 per ton, of which 30 per cent. was for development. The mill consists of thirty 1250-lb. stamps, three Hardinge conical mills, copper-plates, Deister and Wilfley tables, and a cyanide plant which is operated under contract. Milling costs about 79 cts. per ton; concentrate treatment, 28 cts.; tailing treatment, 49 cts.; and marketing bullion, 2 cts.; in all a total of $1.58 per ton.

Colorado.—This State is the third largest gold producer and the fifth in silver. The last 10 years show the following:

Year.	Gold, Oz.	Value.	Silver, Oz.	Value.
1912	899,222	$18,588,562	8,212,070	$5,050,423
1913	877,857	18,146,916	9,325,255	5,632,454
1914	961,845	19,883,105	8,796,065	4,864,224
1915	1,084,323	22,414,944	7,027,972	3,563,182
1916	928,075	19,185,000	7,551,761	4,967,900
1917	772,766	15,974,500	7,291,495	6,004,500
1918	615,558	12,724,700	6,900,266	6,765,435
1919	495,810	10,249,300	5,966,606	6,687,790
1920	363,218	7,508,400	5,166,873	5,674,622
1921[1]	331,354	6,849,700	5,408,273	5,408,273

[1] Preliminary estimate.

Production was fairly well maintained in 1921, in spite of the fact that many small copper, lead, and zinc mines were closed.

Teller County (Cripple Creek), after the heavy setback of 1920, experienced a revival in 1921, owing to the return of many former lessees, who commenced operations on dumps, and began to develop former producing properties; but the results were not apparent in the output, which was $4,300,000 in gold in 1921, compared with $4,323,998 in 1920. The Golden Cycle mill at Colorado Springs was operated continuously, as was the Portland Independence mill at Victor. The Lincoln cyanide mill near Cripple Creek was operated for a time. The Cresson resumed payment of dividends.

Leadville, according to C. W. Henderson, one of the oldest and most persistently producing districts in Colorado, which mines many kinds of

[1] *Eng. Min. Jour.*, 112, 725 (1921).

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ore and shows great fluctuation in production according to changes in the prices of metal, was affected seriously by the low prices of lead and zinc. The Ibex gold-silver mine was operated continuously, but with reduced forces. The Yak mine continued development and made shipments of silver-iron ore.

San Miguel County materially increased its output of gold and silver. At Telluride there was persistent development of milling ores and steady operation of the Smuggler Union mill, which was augmented by the completion of the concrete flotation mill to take place of the one destroyed by fire in 1920. The Tomboy's flotation mill (new in 1920) was operated steadily, and the Liberty Bell's cyanidation mill continued operations until November, when the mill was closed and a final clean-up made. The Belmont-Wagner property, near Telluride, also contributed to the output of San Miguel County and operations were resumed in the Ophir district.

Three dredges at Breckenridge and small hydraulic operations yielded $340,000 in placer gold, as compared with $374,000 from four dredges in 1920, but the zinc mine of the Wellington company, for many years the principal producing property in Summit County, was idle in 1921. Some development work was done at Kokomo.

After several years testing of placer ground, construction was started at Fairplay, Park County, on the hull of a dredge, and an order was placed for machinery, to be delivered in the spring of 1922. The London mine continued to ship gold ore from the upper levels, and a crosscut tunnel 1000 ft. lower than the present workings was almost completed by the end of 1921.

The production of San Juan County was very small, owing to the low price of lead and zinc. The Sunnyside mine and mill, which made a heavy output of lead-silver-gold and zinc-silver-gold concentrates in 1920, was idle in 1921. Production in Ouray County was confined chiefly to the operations of the Atlas, Mountain Top, Hidden Treasure, and Barstow mines.

Gilpin and Clear Creek counties both showed decreases in production. At Black Hawk the old Polar Star amalgamation mill was operated intermittently on gold ores, and the Midwest mine shipped silver ores. The mills at Idaho Springs were not active. The Burleigh mill at Silver Plume was operated successfully on dump ores. Some small shipments of lead and zinc concentrates were made from the Wasatch mill.

Development work in Hinsdale County promises results for 1922. Custer County silver mines continued operation. The Hope Co., a local organization at Aspen, on Castle Creek, after driving a crosscut adit for eight years, struck the contact at a depth of 2200 ft. below the surface and shipped several cars of good-grade silver ore. The Park Co., in Tourtelotte Park, near Aspen, blocked out considerable milling ore and arranged to build a tram to the Hunter Creek mill. The Cowenhowen tunnel, at Aspen, long idle and caved, was completely re-timbered in 1921, and some stope ore was treated at the Hunter Creek mill, which was remodeled by the addition of a ball-mill and flotation cells. The lower levels of the Smuggler Leasing Co.'s properties at Aspen remained under water, but leases continued to produce silver ores from the upper levels.

Eagle County shipped a large quantity of silver-iron ores, but all zinc ore mined was stored. The production of silver in both Boulder and Mineral counties was not equal to that of 1920.

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Idaho.—This State is an important silver but a small gold producer. The former metal is a by-product of lead and zinc ores, the latter is recovered almost equally by dredging and from some small gold mines. The output of gold increased somewhat in 1921, while silver was well-maintained in spite of numbers of base-metal mines being closed. The yearly outputs for some time past are as follows:

Year.	Gold.		Silver.	
	Ounces.	Value.	Ounces.	Value.
1912	66,816	$1,381,214	8,294,745	$5,101,268
1913	65,043	1,344,559	9,989,193	6,033,473
1914	57,431	1,152,315	12,479,516	6,901,172
1915	57,070	1,179,731	11,769,128	5,966,948
1916	51,195	1,058,300	11,570,399	7,611,500
1917	36,511	754,800	11,402,542	9,390,000
1918	33,930	701,400	9,396,009	9,212,411
1919	34,085	704,600	5,933,076	6,650,207
1920	22,668	468,600	7,364,735	8,088,523
1921[1]	25,315	523,300	6,716,892	6,716,892

[1] Preliminary figures.

C. N. Gerry wrote:

The largest output of gold was made by the Gold Hill & Iowa property, at Quartzburg. The dredge of the Yukon Gold Co., at Murray, in Shoshone County, was also a large producer of gold, as it was operated uninterruptedly during 1921. A new dredge was being erected at Featherville, in Elmore County, and preparatory work was done for hydraulicking on a large scale in Boundary County and for dredging in Boise County.

The mine output of silver decreased about 650,000 oz. The largest silver producers in the State were the Bunker Hill & Sullivan, at Kellogg, the Morning mine of the Federal Mining & Smelting Co., and the Hecla mine, at Burke. The Independence mine, in Blaine County, and the Ramshorn property, in Custer County, each produced a large and increased output of silver. Other large producers of silver were the Hercules and Tamarack & Custer mines, which were operated for only three months. The mines in the Coeur d'Alene district produced about 4,800,000 oz. of silver, or about 84 per cent. of the total for the State.

Montana.—The effect of suspension of operations of most of the copper and zinc mines at Butte is reflected in the accompanying table of gold and silver production. This State was an easy first in silver in 1920, but is now second, and far below Utah, which is first. It might be said that silver is nearly all a by-product of the Butte mines; also a good deal of the gold. The Barnes-King company's output of gold fell off considerably, as did that from the Conrey dredges in Alder gulch. Other gold mines were active part of the time.

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Year.	Gold.		Silver.	
	Ounces.	Value.	Ounces.	Value.
1911	179,499	$3,710,571	11,985,196	$6,352,154
1912	175,371	3,625,235	12,731,638	7,829,957
1913	168,995	3,493,432	13,819,201	8,346,797
1914	200,446	4,143,600	12,016,460	6,645,100
1915	240,825	4,978,300	14,423,173	7,195,600
1916	209,386	4,328,400	14,046,054	9,240,100
1917	181,720	3,756,500	13,711,100	9,312,900
1918	158,704	3,280,700	16,378,263	16,058,232
1919	116,918	2,416,900	15,012,258	16,826,700
1920	91,802	1,897,700	13,263,356	14,566,746
1921[1]	80,835	1,671,000	9,168,011	9,168,011

[1] Preliminary figures.

Nevada.—This State being one of the largest producers of gold and silver (sixth and third, respectively) in the Union, its progress is followed closely. The output since 1909 is tabulated below:

Year.	Gold.		Silver.	
	Ounces.	Value.	Ounces.	Value.
1909	785,608	$16,239,963	10,981,061	$5,711,152
1910	913,265	18,878,864	12,479,871	6,739,130
1911	880,106	18,193,397	13,184,601	6,987,839
1912	650,943	13,456,180	14,369,063	8,836,974
1913	570,589	11,795,130	16,090,083	9,718,410
1914	558,064	11,536,200	15,094,432	8,502,662
1915	574,874	11,883,700	14,453,085	7,210,500
1916	438,505	9,064,700	13,682,067	9,000,600
1917	334,894	6,922,900	11,441,000	9,312,900
1918	324,134	6,700,440	9,931,969	9,737,898
1919	225,384	4,659,100	7,046,395	7,896,972
1920	175,451	3,626,900	7,481,866	8,217,109
1921[1]	155,472	3,213,900	6,719,455	6,719,455

[1] Preliminary figures.

In discussing gold, V. C. Heikes stated:

The output from the Tonopah district decreased from $1,056,986 in 1920 to about $982,000 in 1921, on account of a labor strike which interrupted operations from April to August. Production of the Goldfield district also decreased from $155,789 to about $109,750. The Elkoro mine at Jarbidge was the largest producer, the Tonopah Belmont and West End mines ranking next. The gold produced from copper ore was much less than in 1920 on account of the closing of the mill of the Nevada Consolidated Copper Co. in April. Other mines that made an output of gold valued at more than $100,000 each were the Consolidated Virginia, Round Mountain, Tonopah Extension, Rochester Silver, Tonopah Mining, Nevada Consolidated, Elko Prince, Gold Canyon, and Olympic. A large increase in the output of gold was made by the Gold Canyon Dredging Co., at Dayton, which operated a large dredge throughout the year. In Lander County the Homestake placers produced considerable gold. In Clark County, the Techatticup mine was idle, but ore rich in gold was shipped from the Duplex mine. There was much activity in the Comstock district, especially in development work, but the output of both gold and silver was slightly less than that of 1920. The Rochester district upheld its production, though the Nevada Packard was idle part of the year.

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Concerning silver Mr. Heikes wrote:

The large mines of the Tonopah district produced about 4,581,000 oz. in 1921, against 4,816,055 oz. in 1920. The largest producers were the Tonopah Belmont, West End, Tonopah Extension, Tonopah Mining, and Rochester Silver mines. Large quantities of silver were also produced by the Tonopah Divide, Leadville, Consolidated Virginia, Nevada Packard, Comstock Leasing, Montana Tonopah, and Jim Butler mines. Every effort was made, especially at Tonopah, to take advantage of the Pittman price of silver, but the strike at Tonopah and Divide prevented an increased output. Rich silver ore was mined and developed in many camps in 1921. The most prominent were Silverhorn, Lincoln County; Argentite, Klondyke, Hornsilver, and Divide, Esmeralda County; and San Antone, Nye County. In Barcelona district, Nye County, the Consolidated Spanish Belt Silver Mining Co. operated a new mill in November.

The dividends declared by Nevada mining companies for the first eleven months of 1921 amounted to $640,357. The principal contributors were the Tonopah Extension, Rochester Silver, Tonopah Belmont, and Tonopah Mining companies.

According to the *Tonopah Bonanza* the district produced during the year 340,924 tons of ore worth $5,641,371. The Tonopah Divide was operated with little publicity, and reported the following results:

The shaft is 1229 ft. deep; workings total 17,796 ft.; 12,763 tons, worth $301,863 net, was mined in 1921, yielding a profit of $101,559; the total cost was $13.30 per ton; 22,752 tons of $26.48 ore has been treated in two years, and 6346 tons of $11.54 ore is on the dump.

To avoid apex litigation, the Tonopah Extension company acquired the Cash Boy property at the end of 1921. The price was $20,000 cash and 100,000 Extension shares, which, at $1.60, amounts to $160,000, or $180,000 in all.

The United Comstock Mines Co. is an enterprise embracing eleven old properties, covering 10,000 ft. along the Comstock Lode. By the time the development and 2000-ton mill are finished, the cost will be about $2,500,000. A 10,000-ft. haulage-tunnel to link up all the mines has been driven, besides the mill mentioned. Reserves are expected to be 2,200,000 tons of silver ore. Mining will be by the branch-raise system.

Some excitement was caused by the discovery of rich ore in the Silverhorn district, which is about 23 miles north of Pioche in eastern Nevada, and at an elevation of 6500 ft. According to T. H. Crampton,[1] the Nevada Silver Horn is the principal property, where milling ore is now being developed, and estimates place the reserves at several hundred thousand tons of 17-oz. silver ore. The district had been visited by about 25 engineers, and the general opinion was that the disclosures of silver ore were larger than any heretofore discovered in Nevada.

[1] *Min. Sci. Press*, 122, 883 (1921).

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The Hornsilver district was briefly described by J. K. Turner,[1] who said that it was 30 miles southwesterly from Goldfield, and there are two well-developed properties—the Great Western and the Orleans. The former has produced over $500,000, and the latter $450,000. Both have silver ore on the 600-ft. level, the Orleans mining $15 ore from a width of 10 ft. Prospectors are said to be busy in the district.

Some interesting reminiscences of the Comstock Lode in the sixties were given by R. H. Stretch,[2] and will be found of interest to those following the new development in that district.

The Rochester Silver Corporation of the Rochester district arranged to advance funds ($200,000) for erection of a mill at the Argentum mine at Candelaria, and will move its Rochester Combined mill, which has never been operated, thereto. Reserves at the Argentum were estimated as worth $3,436,000. Milling ore (60,000 tons) at the Lucky Hill mine averages 14 oz. of silver and $1 in gold per ton. The Candelaria district, which has produced about 20,000,000 oz. of silver, was described for the first time by Adolph Knopf in *Bulletin* 735-A of the U. S. Geological Survey. The ores are not easy to treat, as they contain manganese, iron, dolomite, and bindheimite.

The placers of the Johnnie district of Nevada, near the border of Clark and Nye counties, and 20 miles east from the California boundary, were described by Charles Labbe.[3] The principal diggings are near gold quartz lodes. Bedrock is 3 to 25 feet deep, and the most satisfactory rock is shale or schist, so lying as to form natural riffles. The gold is coarse and angular, with fragments of quartz. Gravel yields from $2 to $30 per yard.

New Mexico.—While the silver production of this State in 1921 was only about 5 per cent. less than in 1920, gold fell off 60 per cent. The great decline in base-metal operations was partly responsible for this decrease. The following table shows the yield over a number of years:

Year.	Gold.		Silver.	
	Ounces.	Value.	Ounces.	Value.
1912	37,947	$784,446	1,536,701	$945,071
1913	42,663	881,926	1,631,273	985,289
1914	58,974	1,219,100	1,777,445	982,927
1915	70,632	1,460,100	2,005,531	1,016,804
1916	65,306	1,350,000	1,729,917	1,138,000
1917	49,590	1,025,100	1,313,700	1,069,350
1918	33,237	687,080	773,662	758,545
1919	28,319	585,400	851,821	954,781
1920	21,720	449,000	699,745	768,509
1921[1]	10,981	227,000	625,334	625,334

[1] Preliminary figures.

[1] *Min. Sci. Press*, 124, 93 (1921).
[2] *Min. Sci. Press*, 123, 739 (1921).
[3] *Eng. Min. Jour.*, 112, 895 (1921).

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The Pittman Act, fixing the price of silver at nearly $1 an ounce for silver in domestic ores, allowed the Mogollon Mines Co. at Mogollon to continue operations during 1921. The Aztec gold mine at Baldy, for several years a heavy shipper of gold bullion, did not contribute to the output of gold during the year, but continued development work. Placer mining was resumed on Willow Creek, Elizabethtown. The gold and silver mines of Lake Valley and other Sierra County districts continued to make occasional shipments. Much silver ore was shipped from the old Chloride Flat district near Silver City. The shipments of copper-bearing silicious gold and silver ore from Lordsburg were small in comparison with the heavy shipments from that district in 1920. Development work, however, was continued at Lordsburg, and one silver mine was reopened. Shipments of gold and silver ores were made from Gold Hill, north of Lordsburg.

Oregon.—Although there was an approximate decline of 25 per cent. in gold and 48 per cent. in silver from this State during 1921, J. M. Hill of the U. S. Geological Survey states that mining at the end of the year was far from being as depressed as these figures might indicate. The decrease was due largely to curtailment of operations of the Cornucopia and the Homestead Iron Dyke mines, in the eastern part of the State. The lessened activity at the latter was due directly to the depression in the copper market. The dredges in Baker and Grant counties were active and made good returns. The U. S. Metals Co. developed a considerable quantity of silver-copper-lead ore at the Bay Horse mine, near Huntington, and expected to begin shipping from dumps and from the mine in a short while. The Blue Mountain Mines Co., at Bourne, increased its production.

In southwestern Oregon there was a decided midsummer revival of activity in the region tributary to Jackson and Gold Hill. The old Sylvanite mine is being reopened by the Oregon-Pittsburg Mining Co., and the Boswell mine, in the Holland district, by the Boswell Mining Co. The Opp mine, near Jackson, was reopened in July, and the Millionaire, which has been under development for more than a year, has been milling steadily. In addition to these mines a number of others not so well known were under development, and since the middle of 1921 several of them have been making shipments.

Production is given in the following table:

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Year.	Gold.		Silver.	
	Ounces.	Value.	Ounces.	Value.
1912	37,251	$ 770,041	57,081	$35,105
1913	78,740	1,627,710	179,036	106,139
1914	76,887	1,589,400	142,552	78,831
1915	90,321	1,867,100	117,947	59,799
1916	91,985	1,901,500	221,887	146,000
1917	81,144	1,677,400	215,700	175,480
1918	61,228	1,265,700	129,150	126,626
1919	53,029	1,096,200	236,620	265,220
1920	49,714	1,027,700	101,658	111,648
1921[1]	40,079	828,500	55,713	55,713

[1] Preliminary figures.

The Gold Hill district in the southwestern part of the State is reported to be active and promising. Included are the Gold Ridge, Millionaire, and Centennial. The first has a 5-stamp mill recovering up to $1700 a week, while the other two—one a deep mine and the other a placer mine—were re-equipped in 1921 at an expenditure of about $100,000 each. The Millionaire has a mill with two Nissen stamps, crushers, plates and tables.

South Dakota.—Gold production of this State showed a gain of about 30 per cent., due almost entirely to the Homestake recovering from the fire in its mine. This company began the year 1921 with increased activity and in April was working almost at full capacity, according to

GOLD PRODUCTION OF SOUTH DAKOTA

Year.	Ounces.	Value.
1911	359,904	$7,439,874
1912	381,745	7,891,370
1913	354,070	7,319,294
1914	354,782	7,334,000
1915	358,145	7,403,500
1916	361,444	7,471,700
1917	357,619	7,392,600
1918	324,083	6,699,400
1919	255,889	5,289,700
1920	209,842	4,337,800
1921[1]	315,981	6,531,900

[1] Preliminary estimate.

C. W. Henderson. From May the operations continued at full capacity throughout the year. In May also the company resumed the payment of dividends, the first since September, 1919, and continued each month during the remainder of the year. The total is now over $43,000,000. The Trojan mine and mill were in continuous operation throughout the year. The Golden Reward Co. moved the machinery of its cyanidation plant from Deadwood to Terry. Considerable development work was done at other properties during the year, including the Anchor Mountain, where it is proposed to erect a treatment plant.

In describing the current construction program at the Homestake

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mine, R. G. Wayland,[1] the assistant superintendent, said that there were two main divisions in this work—the Ellison shaft and the South mill (described elsewhere in this chapter). At this shaft there will be three underground crushing stations, as shown in Fig. 2, with 48 by 36-inch jaw-crushers. These are to be on the 800-, 1400- and 2000-ft. levels, and

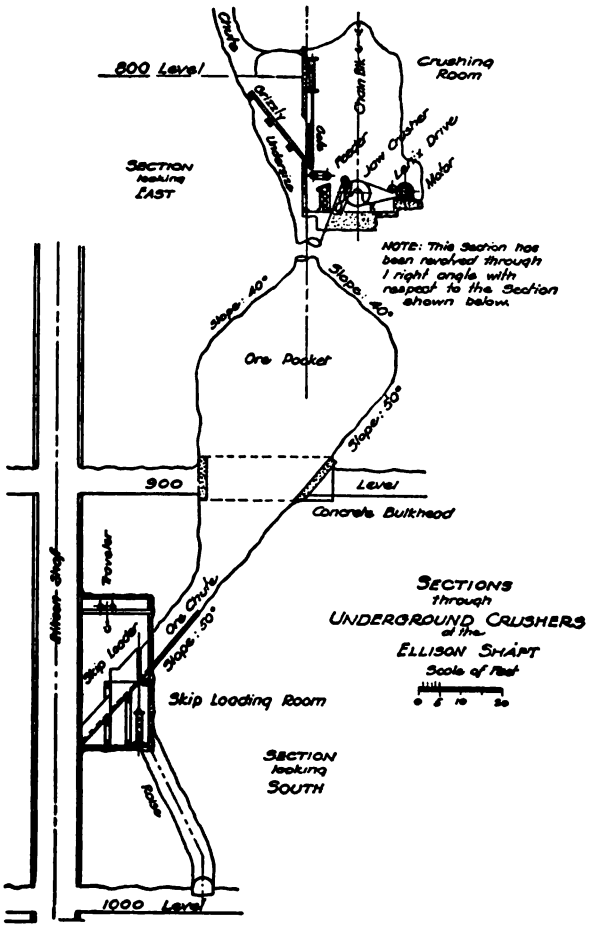

FIG. 2.

will each crush 200 tons an hour. At the mouth of the shaft will be four No. 6 and two No. 4 Gates gyratory crushers, making a 2-in. product. The new South mill is 2000 ft. east of the Ellison shaft.

Texas.—Metal mines in this State produced 544,000 oz. of silver in 1921 as compared with 511,401 oz. in 1920. The principal producer was

[1] *Pahasapa Quarterly*, South Dakota School of Mines, Feb., 1921.

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the Presidio mine, at Shafter, which was operated steadily throughout the year. A very small quantity of gold was also obtained from Texas ores in 1921.

Utah.—Apart from one small gold mine, the Deer Trail near Marysvale, in Piute County, all of the gold and silver of this State come from copper, lead, and zinc mines, according to V. C. Heikes. Production of gold was retarded during 1921 by the shut-down of copper and lead mines. Silver on the other hand, increased considerably. The last 10 years' production of this State are given below.

Year.	Gold.		Silver.	
	Ounces.	Value.	Ounces.	Value.
1912	206,380	$4,265,851	13,835,903	$8,509,070
1913	172,480	3,565,229	13,084,835	7,903,230
1914	163,362	3,377,000	11,154,916	6,168,669
1915	189,045	3,907,900	13,073,471	6,522,200
1916	186,679	3,859,000	13,545,802	8,911,000
1917	175,133	3,620,300	14,315,300	11,652,650
1918	152,526	3,153,000	13,492,555	13,228,911
1919	109,660	2,266,900	12,542,620	14,058,650
1920	102,975	2,128,700	11,755,411	12,910,615
1921[1]	89,184	1,843,600	13,233,658	13,233,658

[1] Preliminary estimate.

At Bingham (output 47,052 oz.) and Park City (output 3317 oz.) the production of gold decreased slightly, but in the Tintic district (output 18,578 oz.) the decrease was marked, as several large producers were idle for months. The United States Mining Co. at Bingham greatly increased its output of gold from lead and copper ore, and its mine produced more than twice as much gold as any other mine in Utah. Second in gold production was the Deer Trail mine, which also had a considerably increased output. Gold in quantity was also produced by the Utah Copper, Chief Consolidated, Eagle & Blue Bell, and Tintic Standard mines.

The decrease in silver was especially noticeable at Bingham, Park City (the yield was 2,185,000 oz.) and Ophir. The output from the Tintic district (7,425,000 oz.), however, was more than upheld, principally through the efforts of the Chief Consolidated and Tintic Standard companies. The Chief Consolidated mine, at Eureka, continued to be the largest producer of silver in the State, yielding over 2,500,000 oz.; and the Tintic Standard followed closely. Other mines that produced more than 500,000 oz. were the United States Mining Co., at Bingham; Vipont, in Box Elder County; the Judge and Ontario mines, at Park City; and the Eagle & Blue Bell, at Eureka. One of the interesting features of the year was the large production of silver ore from the Park Utah mine, east of the Ontario at Park City. The Tintic Milling Co. at

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Silver City continued to treat custom ores by a chloridizing roast followed by leaching, and the Tintic Standard Co., in the eastern section of the district, operated its new mill using the same process. The Deer Trail Gold mine, in Piute County, increased its production of silver, and shipments of silver concentrates from the Vipont mine, in Box Elder County, were also much greater.

The Deer Trail ships a high-grade gold-silver ore to the smelter, but treats the lower-grade ore in a 100-ton mill employing concentration and cyanidation. About 125 men are employed. A lead ore is also mined.

Washington.—According to C. N. Gerry, the output of metals in this State was less than that for any year in the last decade, save that there was a slight increase in gold from 7160 to 8436 oz. Most of the gold came from the Republic district, Ferry County, but shipments of silicious ore were restricted by high freight-rates. The main producers were the San Poil, Knob Hill, and Surprise mines. Late in the year operations were resumed at the Boundary Gold Mountain mine in Whatcom County, and gold bullion was shipped to Seattle. This mine was a large producer in 1916 and 1917.

The mine output of silver decreased from 199,678 oz. in 1920 to about 132,000 oz. in 1921. Mines at Republic, Nighthawk, Chewelah, and Colville produced most of the silver, but the silver from copper ore was unusually small, as the mill of the United Silver Copper Co. at Chewelah was not operated, and the Sunset mine, near Index, was idle. Rich silver ore was opened in the Old Dominion mine near Colville, and ore was milled by the Pyrargyrite and Four Metals companies in Okanogan County.

Wyoming.—All that can be said bearing on precious metals in this State is that owing to the low price of copper the Sunrise iron (copper) mine at Hartville was idle for a part of 1921 and shipped no ore during the year. The Electrolytic (old Rambler) mine at Holmes shipped one car and stored several cars of copper-gold-silver ore awaiting negotiations which, it is hoped, may result in payment for the palladium-platinum content of the ore. No other production was made in Wyoming and very little development work was done.

Gold and Silver Mining in Foreign Countries

Canada

Generally speaking, the figures shown in the table below indicate a healthy condition in gold and silver mining. The gold output for 1921 was the highest in 20 years, and that of silver, while not much of a decline from 1920, is the lowest yield in 14 years. Of course, Ontario is the bright spot, and much better things are expected during 1922.

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GOLD

Year.	Value.	Year.	Value.
1890	$1,149,776	1906	$11,502,120
1891	930,614	1907	8,382,780
1892	907,601	1908	9,842,105
1893	976,603	1909	9,382,230
1894	1,128,688	1910	10,205,835
1895	2,083,674	1911	9,781,077
1896	2,754,774	1912	12,648,794
1897	6,027,016	1913	16,598,923
1898	13,775,420	1914	15,983,007
1899	21,261,584	1915	18,977,901
1900	27,908,153	1916	19,234,976
1901	24,128,503	1917	15,272,992
1902	21,336,667	1918	14,463,689
1903	18,843,590	1919	15,580,423
1904	16,462,517	1920	17,754,487
1905	14,159,195	1921	21,327,000

SILVER

Year.	Ounces.	Cents per Ounce.
1904	3,577,526	57.22
1905	6,000,023	60.35
1906	8,473,379	66.79
1907	12,779,799	65.33
1908	22,106,233	52.86
1909	27,529,473	51.50
1910	32,869,264	53.49
1911	32,559,044	53.30
1912	31,955,560	60.83
1913	31,845,803	59.79
1914	28,449,821	54.81
1915	26,625,960	49.68
1916	25,459,741	65.66
1917	22,221,274	81.42
1918	21,383,979	96.84
1919	16,020,657	111.12
1920	13,330,357	100.90
1921	13,134,926	62.65

British Columbia.—A decline of about 10 per cent. in gold and 25 per cent. in silver, as compared with the figures of 1920, was recorded for the past year. While the output of copper was 33 per cent. lower, that of lead was nearly 10 per cent. higher, and zinc was almost the same as in 1921. Taken as a whole, and considering the low prices of base metals ruling throughout the year, the production cannot be considered as other than satisfactory. The gold output is disappointing, as it generally was expected that it would show an improvement on last year. The Rossland mines have produced more than 20,000 oz. over their production of last year. On the other hand, the Nickel Plate mine has produced nothing, and the Belmont-Surf Inlet mine shows a marked decrease (dividends were $62,500, compared with $250,000). Owing to labor trouble, the Premier mine, from which much was expected, has confined its attention mostly to construction and development work. It was only toward the end of the year that steady production commenced, and the great bulk of these shipments will obtain returns from the smelter too late to appear as 1921 production. During the year the following was accomplished at the Premier; men employed, 382; feet of driving, 4027; feet of drilling, 6821; ore mined, 15,129 tons; gold obtained, 35,000 oz.; silver, 1,200,000 oz; 2 Diesel engines and compressors erected, also a 11½-mile aerial tramway to the coast. An initial dividend of $400,000 was paid for the

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last quarter of 1921, and $500,000 for the first quarter of 1922. The decrease in the silver production may be attributed to the complete collapse of the Slocan and Ainsworth districts, owing to there being no market for the output, and of the Dolly Varden mine, through financial difficulties.

PRODUCTION OF GOLD AND SILVER IN BRITISH COLUMBIA

Year.	Gold.		Silver, Ounces.
	Lode Mines.	Placers.	
1912	$5,322,442	$555,500	3,132,108
1913	5,627,490	510,000	3,465,856
1914	5,109,004	505,000	3,602,180
1915	5,167,934	770,000	3,366,506
1916	4,587,334	580,500	3,301,923
1917	2,367,190	496,000	2,929,216
1918	3,403,812	320,000	3,498,172
1919	3,150,645	286,500	3,403,119
1920	2,481,392	221,600	3,377,849
1921	2,191,000	220,000	2,550,000

Of the precious-metal output of the Province last year, the smelter at Trail recovered 51,037 oz. of gold and 1,173,890 oz. of silver, a 25-per cent. increase in gold and 10-per cent. increase in silver, compared with the yield in 1920. Some of this metal came from the Rossland district, where there was a slightly larger operation.

Gold is the chief ore mineral of economic importance in the Coquihalla area, according to C. E. Cairnes. This district covers a nearly triangular strip of territory drained by the Coquihalla River, which enters the Fraser River at Hope, 91 miles by rail east of Vancouver. At the Aufeas mine the gold is confined to a belt of auriferous slates. It is both free and in close mechanical association with arseno-pyrite, and somewhat with iron pyrite. The Emancipator mine has a 1200-ft. tunnel, 530 ft. of which has been driven along a high-grade quartz vein, somewhat faulted. Highly silicified fragments of country rock embedded in the vein material are often very rich. They impart a bluish cast to the quartz. Two "leads" in slate have been worked at the Idaho mine. A number of other claims are being worked. There are some high-grade silver deposits in the area, notably at the Eureka mine.

The Similkameen district of British Columbia, in which are many workable deposits of gold, copper, silver, and coal, and where the mineral resources are matched by potential agricultural wealth, was described by C. M. Campbell.[1] Near Hedley is the well-known Nickel Plate gold mine, which has produced about 850,000 tons of $12 ore. Abnormal conditions have affected very profitable operations, which will no doubt return. Between Hedley and the International Boundary is the Horn Silver

[1] *Eng. Min. Jour.*, 111, 702 (1921).

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mine, which produces about 1000 tons of 40-oz. silver ore per year. Nearly all the creeks flowing into the Tulameen River contain gold, and the yield is over $750,000 to date.

A promising mine in the Nelson district is that being developed by the Nugget Gold Mines, Ltd., according to G. H. Shepherd,[1] who states that workings cover 6000 ft., and a raise being driven is expected to expose a block of 12,000 to 15,000 tons of good milling ore. There are seven veins, but only two have been opened. The orebodies are lenticular, varying in width from 1 to 11 ft., and with a maximum length of 210 ft.; they exist only in the quartzite, whereas vein continuations through the schist zones are uniformly barren. Oxidation persists to a depth of 1050 ft., but pyrite, chalcopyrite, galena, and sphalerite are encountered. Treatment of the ore will be described under the metallurgical section of this chapter.

Manitoba.—A rush set in late in 1921 to Elbow Lake, 75 miles north of The Pas, and early in 1922 there had been 500 claims staked. The Hollinger company of Porcupine, Ontario, had taken an option on the Murray claims at a high figure.

Both L. G. Thompson and R. H. Hague[2] gave brief reviews of mining conditions in Manitoba during 1921. There was little or no mining proper in the greater Rice Lake district last summer, according to Mr. Thompson, but prospecting in certain areas was very satisactory. A new district, reached from Hole Lake, via Beaver River, was discovered, many good strikes of gold quartz being reported. It is closest to Lake Winnipeg, and is not so inacessible as other areas. A strong vein was opened on the Huronic group. Work was done at the Eva and Lulea, while a 5-stamp mill was brought in for the Gold Pan mine. Mr. Hague considers that the discovery of gold at Elbow Lake, out from The Pas, was of importance; and a large number of claims have been staked in the Pas mineral belt during the year.

Ontario.—Gold production during 1921 was over 25 per cent. in excess of that for 1920, and during the last quarter of the year it was at the rate of $19,330,000 per annum. With considerably augmented milling capacity at both Porcupine and Kirkland Lake the yield for 1922 will be considerably over that of 1921. Operating conditions—labor, supplies, and power—are steadily improving. Two new producers entered the list in the Kirkland Lake field, which contributed 73,773 oz. in 1921 from 136,529 tons of ore. The Porcupine mines treated 1,580,460 tons of ore, but according to W. R. Rogers in *Bulletin* 43 of the Provincial Department of Mines, expansion of milling capacity has been deterred by reason of the uncertainty of an adequate hydro-electric power supply.

[1] *Min. Sci. Press*, 124, 51 (1922). [2] *Bull. Can. Inst. Min. & Met.*, Jan., 1922, 38, 44.

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PRODUCTION OF GOLD AND SILVER IN ONTARIO

Year.	Province. Gold, Oz.	Porcupine. Gold, Oz.	Province. Silver, Oz. (a)	Cobalt. Silver, Oz. (b)
1907	3,212	.....	9,982,363	10,023,311
1908	3,212	.....	19,398,545	19,437,875
1909	1,569	.....	24,822,099	25,897,825
1910	3,089	1,947	30,366,366	30,645,181
1911	2,062	755	30,540,754	31,507,791
1912	85,523	83,725	29,214,025	30,243,859
1913	219,801	207,748	28,411,261	29,681,975
1914	268,264	251,131	25,139,214	25,162,841
1915	406,577	366,574	22,748,609	24,746,534
1916	492,481	452,095	21,608,158	19,915,090
1917	431,355	410,000	19,479,691	19,401,893
1918	411,879	375,806	17,409,263	17,661,694
1919	505,963	481,319	11,363,252	11,214,317
1920	564,995	512,625	10,968,358	10,831,146
1921	707,509	633,557	8,412,059	8,279,320

(a) Dominion Department of Mines figures. (b) Ontario Bureau of Mines figures. The excess of the Cobalt output over that of the whole Province in some years is probably due to different methods of reporting shipments.

The Northern Canada Power Co. has come to an agreement with the McIntyre company to take over the latter's power rights at Sturgeon Falls on the Mattagami River, 28 miles to the north of Porcupine, where a development of 6000 or possibly 7000 horsepower is possible. Work will proceed at once and power should be available by the end of 1922, thereby increasing Porcupine's power supply by about 50 per cent. An increase of milling capacity from 550 to 800 tons is proceeding at the McIntyre; and the Hollinger, which is treating about 4000 tons of ore, also plans an ultimate expansion to 7000 tons daily capacity. Additional power, however, will be necessary, so it has applied for a water-power lease at a point on the Abitibi River, 12 miles north of Cochrane.

Regarding silver, the Cobalt district has produced nearly 323,000,000 oz. since 1904, valued at $198,100,000. Mines shipping over 200,000 oz. of silver in 1921 were as follows: Nipissing, 3,012,614 oz.; O'Brien, 1,408,890 oz.; Coniagas, 1,301,860 oz.; Mining Corporation, 896,627 oz.; La Rose, 658,423 oz.; Keeley (South Lorrain), 281,659 oz.; and Miller Lake O'Brien (Gowganda), 223,468 oz.

According to A. F. Brigham, manager for the Hollinger company, whose mine is producing gold at the rate of $11,000,000 per annum, eight mines in Ontario at the beginning of 1922 were producing at the rate of $20,000,000; and this output is expected to increase when the shortage of power is overcome. Dividends to the end of last year from the Porcupine district totaled $22,355,281, to which the Hollinger contributed $16,558,000, the Dome $2,397,083, and the McIntyre Porcupine $2,548,198.

A review of what the Hollinger mine has done and its future was discussed by Alexander Gray,[1] who also compared it with the New Modder

[1] *Can. Min. Jour.*, Dec. 16, 1921.

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mine on the Rand. The gross income of the company from 1912 to 1921, inclusive, was almost $50,000,000, from 4,900,000 tons of ore. Of this sum, $25,610,000 was profit, and of it, $16,556,000 was distributed in dividends. Eventually the mill will treat 6000 tons daily, but the future is measured by the power available. Labor is plentiful and reserves are ample, and sooner or later the Hollinger will be the leading gold mine of the world.

The Ontario Geological Survey completed an examination of the Cobalt district, under way for a year under C. W. Knight. Although it is said that it should have been done several years earlier, practical results are expected even at this date. The report should be published during 1922.

Yukon.—The decline in gold production, which started 9 years ago, continues in this region. Most of this metal was recovered by dredges and hydraulicking on creeks within a radius of 50 miles from Dawson, and that by the Yukon Gold and Canadian Klondyke companies.

GOLD PRODUCTION IN KLONDIKE

Year.	Ounces.	Year.	Ounces.	Year.	Ounces.	Year.	Ounces.
1896....	14,513	1903.....	592,594	1910.....	221,091	1917.....	177,600
1897....	120,937	1904.....	507,938	1911.....	224,197	1918.....	102,474
1898....	483,750	1905.....	381,001	1912.....	268,447	1919.....	90,705
1899....	774,000	1906.....	270,900	1913.....	282,838	1920.....	72,778
1900....	1,077,553	1907.....	152,381	1914.....	247,940	1921.....	65,991
1901....	870,750	1908.....	174,150	1915.....	230,173		
1902....	701,437	1909.....	191,565	1916.....	212,700		

The Sixtymile and Ladue Rivers area, lying adjacent to the Yukon-Alaska boundary southwest of Dawson, was covered by W. E. Cockfield in Memoir 123 of the Canadian Geological Survey. These rivers are tributaries of the Yukon and White rivers, respectively; gold occurs in placers in the valley bottoms and on benches or terraces along the streams. The Sixtymile area is estimated to have yielded $2,500,000. It was discovered 4 years before the Klondike.

The silver-lead deposits of the Keno Hill area, Mayo district, Yukon, referred to in Volume 29 of MINERAL INDUSTRY, were also investigated by W. E. Cockfield. A good deal of work is being done there, especially by the Yukon Gold Co. and the Alaska Treadwell and Bunker Hill & Sullivan companies, both of which have promising properties. The galena assays from 200 to 500 oz. of silver per ton, in places as high as 2000 oz. The high-grade ore in the transverse fissures offers little difficulty in either finding or extracting. On the upland surface these fissures can often be traced by the iron, manganese, and galena float, which is usually close to the outcrop of the vein. Some of the transverse

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fissures are short and not likely to persist to great depth, but this is compensated for, to some extent, by the large number of these veins. The longitudinal veins are more persistent.

Mexico

The information given under this head is mostly of a general character, as the engineer and capitalist really want to know the present general conditions in the country. While a large number of mines are idle, the production of precious metals was fairly well maintained during 1921, as the following table shows:

Year.	Gold, Value.	Silver, Oz.	Year.	Gold, Value.	Silver, Oz.
1893	$1,305,000	44,100,000	1908	$22,371,200	72,250,000
1894	1,463,000	46,800,000	1909	23,842,900	72,320,000
1895	5,100,000	50,890,000	1910	25,100,000	75,520,000
1896	6,310,000	41,374,000	1911	24,500,000	78,700,000
1897	7,121,000	40,800,000	1912	22,510,000	79,000,000
1898	8,236,000	42,400,000	1913	17,030,000	54,000,000
1899	9,277,000	41,700,000	1914	5,700,000	25,300,000
1900	9,409,000	43,450,000	1915	4,960,000	22,250,000
1901	10,329,316	46,910,000	1916	7,753,000	28,000,000
1902	11,293,524	49,100,000	1917	15,540,000	40,800,000
1903	10,677,500	57,400,000	1918	16,705,000	60,750,000
1904	12,605,300	49,200,000	1919	15,566,000	64,000,000
1905	16,107,100	60,000,000	1920	15,090,000	64,600,000
1906	18,534,700	54,400,000	1921	14,040,000	62,700,000
1907	18,681,100	68,200,000			

The busy centers are El Oro, Pachuca, El Tigre, Parral, Jalisco, and various base-metal districts, a large part of the gold and silver being by-products.

According to S. F. Shaw,[1] mining conditions in Mexico during 1921 were most unfavorable, synchronizing with conditions in the United States, yet the outlook for the near future is improving. The principal drawbacks last year were the great drop in metal prices, high smelting charges, high prices for supplies, inadequate means of transportation, and low labor efficiency. Regarding silver prices, it cannot be said that they are low, being at a level which would have been considered good in 1912. The railroads are not in physical condition to move freight expeditiously. One can travel through the country with safety in the cities and larger towns, but advance information as to roving bandits should be secured before traveling into unsettled or mountainous regions.

Generally speaking, according to D. R. Thomas,[2] the production of other metals in Mexico fluctuates with that of silver. The cost of production has varied greatly with the grade of ore treated, taxes, etc. It is difficult to estimate the average cost of producing silver for any period, as so many variable factors enter the calculations. From 1907 to 1913

[1] *Min. & Met.*, No. 180, 23 (1921).

[2] *Min. & Met.*, No. 178, 39 (1921).

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the cost was about 47 cts. per ounce, in 1919 and 1920, 70 to 80 cts.; and in 1921, 60 cts. Marketing costs were 7, 12 to 18, and 8 per cent., respectively. Hardly any silver producers at present are able to make a profit. Many are closed, and in cases where the operating loss is less than the standby losses, efforts are made to carry on operations for the purpose of holding the organizations together. It is a reasonable assumption that the average grade of silver ore to be treated in the future will be low. More progress may be expected from metallurgical than from mining methods. When conditions return to normal, the cost of producing silver in large and well-equipped plants may be assumed at 50 cts. an ounce, providing the current rate of taxation is maintained. Mr. Thomas considers that the production of silver has reached its zenith, and until the railroads are rehabilitated will be low; then as transportation lines extend into new fields, the output may increase and remain at about 75,000,000 oz. for a considerable time. Most of the present large silver centers have passed the zenith of production, but many isolated properties will produce as soon as transportation facilities are provided.

In March, 1922, it was announced[1] that a decree had been issued by the Mexican Government relieving owners of mining property from the payment of penalties arising from failure to pay taxes on their claims during the revolutionary period. This decree is dated Mar. 10, 1922. The penalties shall be remitted if the property owners pay before July 1, 1922, the taxes assessed for the year 1921 and the first 8 months of 1922; also, such payments may be made in installments corresponding to the amount due for a 4-month period. The decree also provides that this relief be extended to the owners of property whose title thereto has lapsed under Mexican law because of non-payment of taxes, provided the properties shall not have been re-denounced either in whole or in part. Also that owners who have failed to pay taxes due prior to 1921 may, provided they make the payments for 1921 and the first 8 months of 1922, pay arrears prior to 1921 in as many installments as there are 4-month periods in arrears.

In the same publication,[2] D. A. Richardson discussed the Mexican mining law under the new constitution of 1917. The pertenencia, of 100 meters square, is the claim unit. Extralateral rights are not recognized. Exploration must be confined to the areas specified in Federal permits. There are strict requirements as to surveys for title. Foreigners may acquire mineral land except in a prohibited zone. The procuring of titles requires considerable patience.

In discussing results during 1921, Simon Guggenheim, president of the American Smelting & Refining Co., stated that political conditions in

[1] *Eng. Min. Jour.-Press*, 113, 547 (1922).

[2] *Eng. Min. Jour.-Press*, 113, 525 (1922).

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Mexico are better than they have been at any time since 1913; and, as a consequence, the earnings of the company's Mexican mines and works are becoming more stable, and profits are correspondingly improving.

Several interesting papers on Mexican mines and districts were published during the year, and that on Las Dos Estrellas gold mine at El Oro, by T. Skewes Saunders[1] will be found worth study, as so little has been available concerning this property. An extensive system of veins has been developed, the Veta Verde being the principal one. It and its branches occur in shale, which, with the vein, are covered by a cap-rock of andesitic lava, from 80 to 320 meters thick. The Veta Verde averages 12 meters in width to a depth of 600 meters from the cap-rock. The branch veins vary from 0.8 to 3 meters in width. The mine is opened by six tunnels and five and six interior shafts, and 60 kilometers of levels, of which 38 kilometers are open. Positive reserves in 1920 were 429,664 tons, and probable reserves, 399,535 tons. The respective gold and silver contents were 8.59 and 150.8 grams, and 7.00 and 152.0 grams per ton. To the end of 1920 a total of 4,869,878 metric tons of dry ore had been mined. In 1920 the output was 6,415,670 pesos from 361,878 tons, or 17.73 pesos per ton. Costs were 12.17 pesos. In 1912 the yield was 11,237,312 pesos from 507,018 tons. Costs were then 9.20 pesos per ton. The mill of 120 stamps and cyanide plant has a daily capacity of 1250 tons. Extraction is 89.2 per cent. of the gold and 70.4 per cent. of the silver. All mining and milling machinery is electrically driven.

The geology of the Pachuca silver district and the El Oro gold-silver district was discussed by H. V. Winchell at the annual meeting of the American Institute of Mining and Metallurgical Engineers in February, 1921.[2] During its last financial year, the El Oro M. & R. Co. produced 383,043 tons of $7.63 ore. The profit was £74,383 and £57,375 was paid in dividends. Taxes are still oppressive, amounting to $333,297. Costs were reduced by $1 per ton.

According to H. M. Payne,[3] the greatest activity in Mexico is probably in the states of Jalisco and Nayarit. As it will be at least three years before the rail termini at Tepic and La Quemada are connected, the Governments of these two States are constructing an automobile road 15 meters wide between Guadalajara and Ixtlan del Rio, which will serve the mining districts. As far back as 1803, von Humboldt mentioned the Nayarit Mountains as the source of much of the wealth which supported the Spaniards from 1521 to 1821. The Aztecs worked the gold and silver deposits before that time. The geology of the region, owing to volcanic disturbance and subsequent erosion, is decidedly

[1] *Mining Mag.*, **25**, 88 (1921).
[2] *Min. & Met.*, No. 174, 34 (1921); *Trans. Am. Inst. Min. Met. Eng.*, **66**, 27.
[3] *Eng. Min. Jour.*, **112**, 1045 (1921).

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complex. Silver ores predominate, usually as argentite, cerargyrite, or native silver.

The mineral resources of Durango, which is regarded as one of the richest States, were discussed by Manuel Rangel and Alberto Terrones.[1] The Socavon or Mina Grande de Avino silver mine has been worked since 1563. The lack of modern machinery, principally pumping, caused most of the old mines to be closed, even when in bonanza ore. And amalgamation was only suitable for the oxidized ores. The construction of modern mills and railroads to the mining districts may further encourage operators in this State.

At Pachuca, Hidalgo, the Santa Gertrudis mill treated 475,360 tons of ore, yielding 4,533,338 oz. of silver and 21,680 oz. of gold. Of the ore, El Bordo, the new mine, contributed 274,873 tons. Operations were affected by shortage of power, and earnings were lessened by the fall in silver. Reserves at El Bordo are given as 1,319,617 tons, containing 14,651,459 oz. of silver and 61,543 oz. of gold. The Real del Monte mine of the U. S. Smelting, Refining & Mining Co. produced approximately 1,000,000 tons of ore for a yield of 12,000,000 oz. of silver.

The new mill at the Fresnillo mine began operations at half capacity in August, and was expected to be in full working order—75,000 tons a month—at the end of 1921. With silver at 62½ cts., a gross working profit of $75,000 monthly is expected.

Central America

The gold- and silver-producing countries are Honduras, Nicaragua, and Salvador. Their total output of gold and silver in 1919 was $3,300,000 and 2,800,000 oz., and in 1920, $3,000,000, and 2,750,000 oz., respectively. For 1921 the yield is likely to be less, as one important producer in Salvador is not working, and one in Honduras suspended work for a time. Honduras mines yielded $192,248 of gold and 2,000,000 oz. of silver in 1920, and Nicaragua $1,259,387 gold and 410,073 oz. of silver. Nothing of importance was recorded from any of the properties during 1921.

The Pis Pis gold district of Nicaragua was described[2] by Robert Hawxhurst, Jr., who said that before gold was discovered, this region was an unexplored wilderness, the only inhabitants being a few wild Indians. There are now 1500 persons in the district, solely dependent upon mining and allied activities. The gold and silver are very fine, and are associated with pyrite, marcasite, chalcopyrite, galena, and sphalerite. No silver minerals have been identified. The gold content of the 12 veins

[1] *Eng. Min. Jour.*, 112, 168 (1921).

[2] *Min. Sci. Press*, 122, 353 (1921).

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developed is worth from $3 to $10 per ton, with an average of $5. The Eden Mining Co., a subsidiary of the Tonopah Mining Co. of Nevada, started milling ore in November, 1918. This property was fully developed and equipped, and to January, 1920, represented an investment of $2,641,642. At the end of 1919, ore reserves were 115,161 tons, averaging $11.41 per ton. Redemption of the capital expenditure would require 20 years, and 1,000,000 tons of $18 ore, which is impossible in that district. It is concluded that the Eden was foredoomed at its inception, either through failure to recognize the surficial nature of the deposit or to investigate persistence at depth.

South America

In 1919 Bolivia, Brazil, Chile, Colombia, Ecuador, the Guianas, Peru, and Venezuela together produced a total of $13,297,000 of gold and 14,753,000 oz. of silver, and in 1920, $12,246,000 and 13,763,000 oz., respectively. Operations during 1921 were conducted at above the average in other countries, so the output should be fairly well maintained.

Bolivia.—While the gold output is negligible, a matter of a few thousand dollars, the silver amounts to around 2,250,000 oz. per annum. Much of this is recovered from the tin-silver ores, previously described in Mineral Industry.

Brazil.—St. John del Rey and Ouro Preto worked steadily during 1921, and the Republic produced about 100,000 oz. of gold.

The silver output of this country is a matter of only 23,000 oz. per annum.

George A. Packard[1] discussed Brazil as a mining country, and showed that the region is poorly mapped and only partly explored, and while railroad facilities are inadequate waterways are largely used. Only two gold mines of a half dozen working are worth mentioning, these being the Morro Velho (St. John del Rey) and Passagem (Ouro Preto). A depth of 6300 ft. has been reached by the former, which has been operated since 1834. The ore in the Passagem contains considerable arsenical pyrite, yet an extraction of 88 per cent. is maintained.

Chile.—The last two years' output of gold and silver has averaged $730,000 and 1,850,000 oz., respectively, and 1921 will show a decline on those figures. Since 1908, most of the silver has come from copper mines, and in 1917, out of 53,393 kg., only about 20 per cent. was extracted from silver mines proper. Improved methods of recovery are suggested, particularly cyanidation, which has yet to be seriously introduced in Chile.

[1] *Eng. Min. Jour.*, 112, 45 (1921).
[2] *Eng. Min. Jour.*, 112, 45 (1921).

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In a history of mining in Chile, by F. Benitez,[1] will be found a brief review of mining gold and silver in that country since the Spaniards arrived there in the 16th century.

Colombia.—Prospects in this country are attracting attention, both in placer and lode mines, and returns are sure to advance during the next year or so. The returns from dredges and mills are substantial, and are averaging almost $6,000,000 in gold and 500,000 oz. of silver per annum.

The South American Gold & Platinum Co. now has three dredges operating on the San Juan River. The Oroville Dredging Co.'s Pato and Nechi dredges worked steadily during the year. This company controls the Colombian Corporation, which operates the Constancia lode mine. Reserves above No. 3 level are estimated as 300,000 tons of $6 to $8 ore, and 70,000 tons of $8 to $10 ore between No. 3 and 4 levels. A 300-ton mill has been constructed, and costs are estimated to be $3 per ton on that basis.

Guianas.—The British, Dutch, and French areas have been inclined to fall back in gold production (silver is negligible), declining $300,000 from 1919 to 1920. The new dredge of the Guiana Development Co. in British Guiana should make a noticeable gain in the near future. French Guiana produces nearly twice as much as the other two countries.

Peru.—This country is a considerable producer, accounting for about $1,300,000 in gold and 10,000,000 oz. of silver annually, largely as a by-product from copper mines. Nothing of import was reported during 1921.

Venezuela.—Nothing has been published concerning this country of late, and it is presumed that the gold yield was about the usual $500,000.

Africa

Congo.—In the remote northeastern corner of the Belgian Congo is a goldfield which is producing about £400,000 per annum.[2] This is the Kilo field, as shown in the accompanying map, and it is more or less of a mystery. The mines are partly state-owned, and the Congo Government has not induced prospectors and others to flock to the region. Neither has investigation or publicity been courted. It is understood that the fields are extensive, their producing potentialities are large, and a good deal of machinery has been sent there. The prevailing rocks are granite, hornblende syenite, micaceous schist, greenstone, and diorite. Outcrops of quartz and quartzite are scattered throughout. The problem of transportation is of vital import, and motor-roads have been and are being constructed. Communication with the outside is by wireless

[1] *Mining Mag.*, **25**, 287 (1921).
[2] *Min. Sci. Press*, **122**, 606 (1921); abstract from *So. Afr. Min. Eng. Jour.*

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and a 125-kilometer motor-road to Kasenyi, on Lake Albert. Two railways are projected. Production has been as follows:

Year.	Gold, Oz.	Year.	Gold, Oz.	Year.	Gold, Oz.
1905	675	1911	20,543	1917	57,615
1906	6,815	1912	22,505	1918	67,180
1907	10,545	1913	.....	1919	108,400
1908	9,998	1914	33,675	1920	96,800
1909	21,090	1915	52,196	1921	100,000[1]
1910	28,163	1916	52,685		

[1] Estimated.

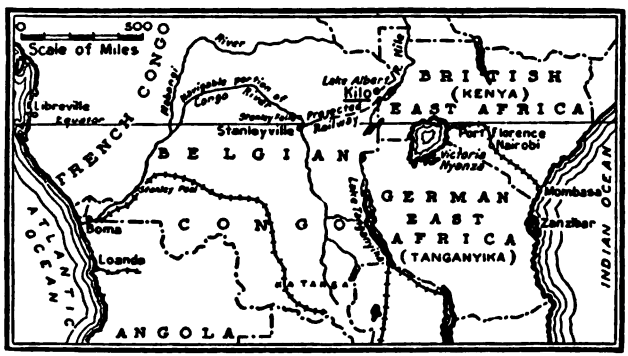

FIG. 3.—Map showing location of Kilo goldfield.

Rhodesia.—To the end of 1921 this country had treated approximately 34,500,000 tons of ore yielding 12,200,000 oz. of gold, valued at £50,000,000. Last year the yield was more than maintained in spite of a general strike of workers for a month early in the year. The silver output was about 153,000 oz. Dividends from gold mines amounted to £572,060. The table gives the gold output for a number of years.

PRODUCTION OF GOLD IN RHODESIA

Year.	Value.	Year.	Value.
1901	£640,000	1912	£2,707,000
1902	744,000	1913	2,903,000
1903	870,000	1914	3,530,000
1904	1,000,000	1915	3,823,000
1905	1,500,000	1916	3,889,000
1906	2,060,000	1917	3,495,000
1907	2,170,000	1918	2,652,000
1908	2,525,000	1919	2,499,500
1909	2,622,000	1920	2,340,000
1910	2,568,000	1921	2,510,000
1911	2,648,000		

Regarding the strike, it may be said that the companies won the day. The unions signed an agreement to the effect that they recognize the

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right of companies to employ whom they please. There is to be no change in the color bar. Conferences, if the topics are important, are to be held by the companies and unions, but if of little moment, are to be settled by the mine managements and men.

Transvaal.—In spite of a steadily decreasing premium on gold and threatened labor troubles, the gold output of the Rand during 1921 was well maintained. The supply of native labor was also good, as the 159,671 Kaffirs employed at the end of 1920 had been increased to 177,836 at the end of 1921. The average value of the ore treated was 28s. 8d ($6.88) per ton, while the cost was 25s. 8d ($6.16). The premium totaled £7,510,600, equal to 6s. 5d. ($1.54) per ton, or £346,000 more than the dividends paid. At the normal price of gold there would have been a loss of 3s. 5d. (82 cts.) per ton—that is 6s. 5d. less 3 s., the margin

TRANSVAAL GOLD PRODUCTION
Witwatersrand District

Year.	Tons Milled.	Value.	Value per Ton Milled, Shillings.	Outside Mines, Value.	Total Value for Transvaal.	Dividends.
1884–89	1,000,000	£2,440,000	48.8	£238,231	£2,678,231	
1890	730,000	1,735,491	47.4	134,154	1,869,645	
1891	1,154,144	2,556,328	44.2	367,977	2,924,305	
1892	1,979,354	4,297,610	43.3	243,461	4,541,071	
1893	2,203,704	5,187,206	47.0	293,292	5,480,498	
1894	2,830,885	6,963,100	49.2	704,052	7,667,152	
1895	3,456,575	7,840,770	45.2	728,776	8,569,555	
1896	4,011,697	7,864,341	39.2	739,480	8,603,821	
1897	5,325,355	10,583,616	39.7	1,070,109	11,653,725	
1898	7,331,446	15,141,376	41.3	1,099,254	16,240,630	
1899	6,872,750	15,067,473	48.8	661,220	15,728,693	
1900 Boer War	459,018	1,510,131	65.8	.....	1,510,131	
1901 Boer War	412,006	1,014,687	49.2	81,364	1,096,151	£100,059,205
1902	3,416,813	7,179,074	42.0	74,591	7,253,665	
1903	6,105,016	12,146,307	39.8	442,941	12,589,248	
1904	8,058,295	15,539,219	38.5	515,590	16,054,809	
1905	11,160,422	19,991,658	35.8	810,416	20,802,074	
1906	13,571,554	23,615,400	34.8	964,587	24,579,987	
1907	15,523,229	26,421,837	34.0	981,901	27,403,738	
1908	18,196,589	28,810,393	31.6	1,147,217	29,957,610	
1909	20,543,759	29,900,359	29.1	1,025,429	30,925,788	
1910	21,432,541	30,703,912	28.5	1,297,823	32,001,735	
1911	23,888,258	33,543,479	28.1	1,498,006	35,041,485	
1912	25,486,361	37,182,796	29.2	1,574,765	38,757,560	
1913	25,628,432	35,812,605	27.8	1,545,435	37,358,040	
1914 World War	25,701,954	34,124,434	26.5	1,463,641	35,588,075	£8,073,436
1915 World War	28,314,579	37,264,992	26.3	1,362,469	38,627,461	7,619,416
1916 World War	28,525,252	38,107,909	26.7	1,377,025	39,484,934	7,095,066
1917 World War	27,251,960	37,017,633	27.1	1,306,288	38,323,921	6,556,188
1918 World War	24,922,763	34,823,017	27.9	945,671	35,768,688	5,330,966
1919	24,043,638	34,454,478	28.7	929,496	35,383,974	6,287,200[1]
1920	24,836,000	33,979,000	27.4	885,000	34,864,000	8,314,300[1]
1921	23,746,988	33,681,250	28.7	807,000	34,488,250	7,164,000[1]

[1] Increase due to exchange premium on gold sold in open market.

between the value per ton and operating cost; so, as aptly put,[1] the prosperity of the Rand depends entirely upon the adventitious aid given by the discount on the paper pound sterling. Thirty companies paid dividends. Including the gold premium, the Transvaal has received £709,467,217 for its gold to date.

[1] *Min. Sci. Press*, 124, 386 (1921).

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Under the caption of "At the Cross Roads of Industry" the *South African Mining and Engineering Journal*[1] showed by diagram that of the £672,027,841 of gold extracted from 1887 to September, 1921, £523,541,872 was expended on wages, stores, and taxation; in other words, 16 shillings out of every pound sterling, or 80 per cent. And in discussing the future it said that the first essentials for the profitable mining of the low-grade ores are lower working costs, larger output, and freedom from irksome and unnecessary trades-union restrictions. It is fairly certain that the last word has not yet by any means been said either in regard to surface or underground practices. There is still plenty of scope for improvement, and if the industry were not constantly harassed by labor troubles, technical men would be more encouraged to experiment in new directions and to apply the results of their researches to the mines. Moreover, the industry should not be dependent on the incidence of such an ephemeral and abnormal factor as the gold premium.

The same journal[2] asked "What's Wrong with the Rand?" and by means of diagrams showed that the men work 25 minutes less than in 1914; working costs increased £11,666,709 in 1921 above that of 1914; the increase in revenue from the gold premium was £2,500,000, but the gain in working costs due to white labor was £5,000,000; and while the cost of producing an ounce of gold was 53s. in 1914, it was 76s. 7d. in 1921.

By means of a graph[3] showing the fluctuations in the gold premium over a period of 6 months, it was shown that when the price of gold falls to 100 s. per ounce, 16 mines will operate at a loss, affecting 5800 white employees; at 90s., 26 mines and 12,000 employees; and at 85s. (normal), 31 mines will no longer pay for working, thus affecting 14,400 employees. Realization charges on gold during 1920 fluctuated widely—from 6d. (12 cts.) to 8s. 9d. ($2.14) per ounce.

For the best essay on how to reduce working costs and improve efficiency in and on the mines of the Witwatersrand, the *South African Mining and Engineering Journal*[4] offered a prize of £25, which was won by John Moore of the Crown Mines. His suggestions were that on the surface all scrap iron and steel be re-melted at a central point, and elimination of overlapping authority and petty foremen. Underground, worn and broken tools should be repaired more than they are; old rails and pipes could be used in place of timber; and when traveling ways must be kept open, mine rock could be used in building walls to support the roof, etc.

The subject of mining efficiency on the Rand was also discussed by

[1] **32**, 461 (1921).
[2] **32**, 1597 (1921).
[3] *So. Afr. Min. Eng. Jour.*, **32**, 1223 (1921).
[4] **32**. 1529, (1921)

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F. C. W. Ingle before the South African Institution of Engineers,[1] who covered shoveling and tramming, hammer-boys, machine-boys, and the instruction of native labor. The waste and misuse of supplies and fittings amounts to a large sum.

The mineral industry of South Africa was discussed by Owen Letcher,[2] who said that the most casual student of mining on the Witwatersrand knows the Main Reef series has passed its zenith of prosperity. The old rich outcrop section has ceased to exist; the first row of deep-level mines has become almost exhausted over the greater portion of the Central Rand; and even in some of the others a lack of profitable ore, greatly hastened by the advance in operating cost, is imminent. The principal developments today are taking place in the eastern annex of the old Central Rand, known as the Far East Rand. Here there are 11 producing mines which are earning nearly 75 per cent. of the profits of the whole Rand. In addition, the New State Areas mine will commence production by the middle of 1923. Development exposures in the Far East Rand, except in the rich sub-outcrop section of the Modderfontein mines, have not disclosed more than 55 per cent. of pay ore. In the Western Rand, the one bright spot is Randfontein. This group has been reorganized and is being developed to supply a 600-stamp mill. It must be admitted that conditions are unsatisfactory, the industry being kept alive by the gold premium. The present average recovery of all mines is 6½ dwt. ($6.50) per ton, and working costs are 26s. ($6.25), so it is obvious with gold at normal price (85s. or $20.67) the Rand as a whole would be an unprofitable affair. The premium has been the salvation of the low-grade mines, and only five mines in the Far East Rand would be able to continue paying dividends. Reduction in operating costs is the greatest need of the day. During the war, industrial peace was maintained by making large concessions in wages and hours. It was "peace at any price," which has continued since the war, resulting in undermined discipline. Early in 1921 the labor forces attempted to bring about a big demonstration on the eve of Parliamentary elections, and overstepped the mark by causing a series of ill-timed strikes. Since then the Transvaal Chamber of Mines stiffened its policy and initiated a policy of greater efficiency.

Gold production will be seriously affected during 1922 as a general strike of labor in the gold and coal mines of the Transvaal began on Jan. 14. The Federation of Workers complained that non-union men were being employed, and there is a dispute over some conditions connected with the employment of native labor. The strike was precipitated through an attempt by the mining companies to reorganize their working

[1] *So. Afr. Min. Eng. Jour.*, **32**, 1223 (1921). [2] *Min. Sci. Press*, **122**, 298 (1921).

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forces by greater employment of native labor, particularly in the semi-skilled occupations, in order to lower working costs. By February, 16 per cent. of the natives had been repatriated. In March, open civil war raged for a time, during which several hundred whites were killed and wounded. The strikers formed commandoes, both infantry and mounted, and were well armed. This condition resulted from radicalism, the absolute necessity for cutting labor costs, and the talk of removing the color bar, whereby more natives would be employed on skilled or semi-skilled work.

Gold production for the first quarter of 1922 was only 639,000 oz., normally only one month's output, showing the effect of the labor crisis. In April the yield was 511,000 oz., a good step toward normal working.

Another happening of considerable importance was the shutting down of the Daggafontein mine in what is known as the Farther Far East Rand. The sum of £879,000 was spent in shaft-sinking, permanent haulageways, equipment, and development; and £1,220,000 for all purposes, but without any return. No technical difficulties have arisen, but it is impossible to secure more funds at present.

Some interest is evidenced in the Far West Rand, at the West Rand estates or Pullinger property. A good deal of ground has been prospected, yet west of Pullinger's is 4 miles of unprospected ground. A new company, the Western Rand Gold & Land Co., has been organized for this section.

"The Crisis on the Rand Gold Fields" is the title of a brochure which was issued by the Transvaal Chamber of Mines, in February, 1922. It has been printed in both official languages (English and Dutch) and sets forth in clear and lucid style what is termed "an outline of the case for the Chamber of Mines in its dispute with the South African Industrial Federation." Within the 30 pages of this book are set forth all the essential facts and figures which are required for a proper understanding of the more recent history of the industry, the plight of the low-grade mines, the dependence in large degree of the whole of the Union upon the gold-mining industry, and the remedies proposed by the Chamber.

The Chamber of Mines in effect has proposed that about 2000 white employees be gradually retrenched, which is absolutely necessary for the welfare of the industry; but the Industrial Federation's demands meant the inevitable dismissal of 10,000 whites.

A symposium on miners' phthisis was held during March by the Chemical, Metallurgical, and Mining Society of South Africa,[1] during which Dr. A. J. Orenstein, Dr. A. Mavrogordato, C. J. Gray, Lionel

[1] *Journal*, **21**, 158, 188, 200.

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Harris, James Chilton, and H. A. White spoke. The injury from dust is still serious, and its prevention is one of the greatest problems facing Rand operating companies. At a meeting in April, E. S. Hendrikz. E. M. Weston, W. Allen, and H. C. F. Bell contributed further remarks. In May, H. J. Ireland spoke on the dilution of dust by excessive ventilation. The discussions were general; some suggestions were made regarding improvements in drilling, but no conclusions were formulated.

Coal beds and gold-bearing reefs are mined in the Far East Rand area, the vertical distance apart being 4000 ft., according to T. N. Dewar,[1] and while the collieries are singularly free from firedamp (methane or CH_4) the death roll from explosions can almost entirely be credited to the gold mines. The Brakpan, Government Gold Mining Areas, and Daggafontein mines have all been troubled with firedamp. The basins of coal-bearing "karroo" rocks in the Far East Rand overlie the dolomites, which in turn overlie the Witwatersrand series. The Brakpan colliery worked over the present Brakpan gold mine, but the other four collieries nearby have no gold mining going on under them at present. Three new shafts of the Springs Mines company have well-developed coal measures in them, but no firedamp has been found in this mine, which probably later will work under an abandoned colliery. Wm. Dewar advanced several theories as to the origin of the firedamp, one being that where carbon occurs at the contact of the reef and the shale, there, especially if associated with pyrite, some reaction may take place with moisture to form something akin to firedamp, which theory was supported by C. J. Gray and G. A. Watermeyer.

Uganda.—The first annual report of the Geological Department of the Uganda Protectorate, by E. J. Wayland and W. C. Simmons, includes the following on gold:

> Gold is widely distributed, but so far has not been found in quantity. It occurs mostly as alluvial. A banket formation was found in the Buganda Kingdom. No attempt has been made to work the lodes found. There are possibilities in pyritic quartzite, banket, quartz veins, highly acid igneous intrusions, and metamorphic rocks of the Archean complex. Alluvial, rather than lodes, will probably be the most profitable undertaking. Other rock associations for gold are granite with diorite intrusions and pegmatites, hornblende schist, and mica-schists.

West Africa.—The companies in this region operated steadily during the year, and treated about 350,000 tons of ore for 240,000 oz. of gold. Economical, metallurgical, and labor problems are always more or less present, yet the various managements do remarkably well.

[1] *Jour. Chem. Met. Min Soc. So. Afr.*, **21**, 127 (1921).

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ASIA

Burma.—The Burma Corporation has invested approximately $70,000,000 in its mines at Bawdwin and its smelter and concentrator at Namtu, yet in 17 years it has not paid a dividend. The best of technical advice has been available, but there is a regular shortage of labor from May to November, and the vagaries of rupee exchange affect revenue and costs considerably. Ore reserves are estimated as 4,400,000 tons, averaging 24 oz. of silver per ton, besides lead, zinc, and copper. There is here, therefore, a potential reserve of 100,000,000 oz. of silver. The ultimate annual production of silver is to be 4,500,000 oz., and during 1921 the output was about 3,600,000 oz., compared with 2,870,000 oz. in 1920.

In describing the mining possibilities of Burma, H. D. Griffiths[1] stated that from 1905 to 1919, inclusive, that country produced a total of 55,140 oz. of gold valued at £4 ($19.20) per oz. The year of greatest production was 1909 with 8488 oz., while in 1919 it was only 38 oz.; but a great deal of the gold is not declared, so that the Government has no definite figures. There are many thousands of natives working gold gravels in various parts of the country, but the occurrences may be classed into three groups—the Upper Chindwin, Bhamo, and River. Along the Uyn Chaung River, a tributary of the Chindwin, the gold is associated with platinum. Exploitation of this district is rendered difficult by reason of floods; no work is possible during the rains, fever is bad, and the local natives are unsuitable for steady employment. Two syndicates did some work there, but were not properly organized to meet other difficulties. The Bhamo district is very accessible, and there are many miles of original deep gold-bearing gravel. Extensive hydraulicking of "re-sorted" gravel yielded 33 to 45 cts. per cu. yd., and a large number of drill-holes averaged 25 to 33 cts. per yd. This re-sorted gravel carries gold from the top, and the increase with depth is rapid. Three properties are being exploited by the Tavoy Tin Syndicate, and one contains over 150,000,000 yd. of 25-ct. gravel, another has 30,000,000 yd. of 33-ct. gravel in old terraces, with 2000 acres of dredging ground, while the third property has 3000 acres of gravel. Mr. Griffiths believes that if these properties were in the United States there would be many dredges in operation thereon. Conditions are good for dredging. The River district—the Irrawaddy and adjacent areas—is somewhat difficult to work, yet prospects are considered good.

Dutch East Indies.—Gold ore is mined in Borneo, Celebes, and Sumatra, that treated in the last-named island yielding considerable silver.

[1] *Mining Mag.*, **25**, 339 (1921).

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The following table shows production during the last few years in guilders or florins (42 cts. U. S. normal exchange):

Year.	Gold, Guilders.	Silver, Oz.
1916	6,285,631	.....
1917	6,415,357	.....
1918	5,230,696	.....
1919	4,748,005	1,006,000
1920	4,550,000	1,027,000

In the Celebes, the Paleleh mine yields about 500,000 guilders annually; Totok, 250,000; and Bolang Mongondau, 450,000 from 16,000 tons.

In Sumatra are the Redjang Lebong, Simau, and Aequator mines, which produced 132,769, 335,946, and 350,370 oz. of silver, respectively, during 1920. Redjang is just about maintaining its yield, but the others are gaining fast. In the Benkoelen district is the Gedang Ilir mine, owned by the Government, and containing a large tonnage of manganese-silver ore, which eventually will be treated by the Caron process of calcining the ore in producer gas, thus freeing the silver for cyanidation.

India.—Reference to the table following will show a gradual decline in the gold extracted from the Kolar group of mines, yet the regularity has been astonishingly good, and the mines are capable of a large production in the future. There is nothing of moment to chronicle concerning the past year's operations.

PRODUCTION OF GOLD IN INDIA

Year.	Value.	Year.	Value.
1893	£870,000	1908	£2,158,000
1894	600,000	1909	2,167,000
1895	730,000	1910	2,105,000
1896	1,200,000	1911	2,150,000
1897	1,500,000	1912	2,265,000
1898	1,620,000	1913	2,300,000
1899	1,740,000	1914	2,340,000
1900	1,930,000	1915	2,370,000
1901	1,960,000	1916	2,300,000
1902	2,100,000	1917	2,214,000
1903	2,380,000	1918	2,080,000
1904	2,440,000	1919	1,950,000
1905	2,490,000	1920	1,890,000
1906	2,500,000	1921	1,657,000
1907	2,160,000		

Japan.—This country, including Formosa, but excluding Korea, which is producing about $3,000,000 of gold per annum, reports over $5,000,000 of gold and 5,000,000 oz. of silver yearly. Early figures for the past year are impossible to secure, so approximate data has to suffice.

The Bajo mine, in Kyushu, 60 miles south of Moji, in Japan, produced 41.713 oz. of gold and 427,946 oz. of silver during 1920, according to N. Ishikawa and H. Kitamura.[1] Six hundred men are employed. The

[1] *Eng. Min. Jour.*, 112, 966 (1921).

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owner is the Narukiyo Mining Co. The deposit was discovered in 1630. The veins consist of quartz in andesite and granite. Gold and silver are associated with all sulphides—which are irregular—but with a pronounced affinity for chalcopyrite and stephanite. The gold content varies from 1¾ to 3½ oz. per ton, and the silver from 7 to 14 oz. Development is performed through vertical and incline shafts, and they are well equipped. The ore is sorted and part is sent to the Saganoseki copper smelter, while the remainder is treated in a mill at the mine.

Korea.—According to a British Consular Report of July, 1921, gold-mining conditions in Korea, after a period of prosperity, are now precarious. The principal adverse factors given were (1) increased cost of labor and supplies; (2) provisions of the Mining Law of 1915 adverse to foreign enterprise; (3) taxes of various kinds; (4) restrictions on cutting timber for fuel purposes; (5) the financial depression; and (6) bad transportation facilities. Wages have been increased 50 per cent., and hours cut from twelve to eight per shift. The Korean laborer is restless now, since the political troubles of 1919. Gold mining is principally in foreign hands, mostly American capital, which operates the Oriental Consolidated, Seoul, and Chiksan properties. British capital controls the Asian Mines, but only prospecting has been done. A French concession is milling ore 15 miles northwest of Unsan. All of the Japanese companies that were mining gold ores have failed. The Japanese Government, it is said, is alive to the difficulties of the situation, and appears anxious to encourage foreign capital, of which there is great need at present. Suggestions have been made for relieving present taxation and other restrictions, and something may be done in the matter.

Malaya.—Production figures are never available early enough to include in this chapter, but in 1920 the output was 12,823 oz. of gold (12,023 oz. from the Raub mine), 16,402 oz. in 1919, and 18,309 oz. in 1918.

Siberia.—So little information on mining is available from this country of unrest, and statistics are so unreliable, that gold mining must be dismissed briefly. Progress may be judged from the table below, but it

Year.	Value.	Year.	Value.
1891	$24,131,000	1907	$26,684,300
1892	20,921,000	1908	28,052,200
1893	21,869,000	1909	32,381,300
1894	20,985,000	1910	35,579,600
1895	18,812,000	1911	32,151,600
1896	31,005,000	1912	22,199,000
1897	21,538,000	1913	24,578,000
1898	24,734,000	1914	26,508,000
1899	23,963,000	1915	28,586,000
1900	23,090,000	1916	22,500,000
1901	25,911,000	1917	18,000,000
1902	24,460,000	1918	12,000,000
1903	24,634,200	1919	11,000,000
1904	24,803,200	1920	1,500,000
1905	22,292,000	1921	2,000,000
1906	19,496,500		

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is unsafe to make any estimate for 1920 and 1921. The U. S. Bureau of the Mint reports only $1,447,000 for 1920, a big decline from the $11,000,000 in 1919.

One of the largest foreign companies operating in Russia (Siberia) is the Russo-Asiatic Corporation, which controls the Kyshtim and other large mines, but is shut down on account of present conditions in that country. Negotiations were started with the Soviet Government with a view to resuming operations, but after lengthy interviews and correspondence,[1] in London and Moscow, it was found impossible to arrive at a settlement. The letters of Leslie Urquhart, chairman of directors of the Corporation, to the Soviet representative and to the shareholders throw a lurid light on the real economic plight of Russia.

By January, 1922, it was reported that the corporation's agent at Moscow had been officially informed that the Soviet Government desired to renew negotiations for the return of the property to its rightful owners and to arrange for resumption of production.

Mining in Siberia and the Russian Far East, in a narrative of personal experiences under the Bolshevist regime, was discussed by L. Heyman,[2] who lived in Siberia during four years. Bolshevism has seriously handicapped and almost ruined even primitive Russian mining, as it has other forms of endeavor in that country. At the commencement of the World War, gold was being mined throughout the entire length of Siberia. Production during certain years is shown in the table below in ounces:

Year.	Ural.	Western Siberia.	Eastern Siberia.	Total.
1879	369,000	91,000	1,089,000	1,549,000
1910	379,000	140,000	1,766,000	2,285,000
1914	317,000	147,000	1,952,000	2,416,000
1917	46,000	19,000	1,036,000	1,101,000
1918	147,000	13,000	556,000	716,000
1919	19,000	26,000	359,000	404,000

Although no definite figures are known for 1920, Mr. Heyman was informed that Eastern Siberia produced about 98,000 oz., although 164,000 oz. was mentioned in another quarter.

There was little hope of improvement in mining conditions at the middle of 1921; in fact, affairs were growing worse. Wherever the Bolsheviki had attempted to operate gold mines the inevitable result was a shutdown, the result of incompetence, lack of discipline and organization, and

[1] *Min. Sci. Press*, **123**, 676 (1921).
[2] *So. Afr. Min. Eng. Jour.*, **32**, 1157 (1921).

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carelessness. The mineral resources are considered to be enormous, and under responsible government the country should again be a great gold producer.

Placer-mining conditions in Russia (Siberia and the Urals), as conducted by foreign companies, were discussed by L. A. Perret,[1] who said that in spite of heavy expenditures the British, French, and German ventures mostly proved failures. The British have contributed most of the capital, starting in 1889, but the enterprises were American from a technical point of view. The factors that led to the failure of these "Anglo-American" projects were (1) ignorance of the Russian language; (2) ignorance of local customs; and (3) disregard of Russian mining methods. Placer mining has produced 90 per cent. of the Russian gold output. Mr. Perret then discusses previous papers by J. P. Hutchins and C. W. Purington, and thinks that although improvements introduced at Lenskoie (Lena goldfields) had a great influence in reducing costs, yet the record output in 1915 was due mainly to extensive preparatory work done by Russian engineers. The efficiency of Russian labor is considered equal to that of the Alaskan miner. Then Mr. Perret covers drifting and timbering methods, washing plants, prospecting, and dredging, including the boats of the Orsk goldfields. Finally, he says that foreign placer mining in Russia has always been on foreign lines, economically as well as technically, and with utter disdain of Russian methods. This has resulted in a loss of large sums of money. Mines where Russian methods are in vogue have yielded large profits. This contrast, he considers, should induce reflection, and to avoid waste of money Russian experience should be combined with American energy and business insight.

G. L. Holmes[2] replied to Mr. Perret, pointing out the advantages of electric over steam power on dredges and he was backed by A. C. Ludlum,[3] who considered that the erroneous conclusions of Mr. Perret had been well set forth by Mr. Holmes, and then analyzed Mr. Perret's figures, to the latter's disadvantage. W. E. Thorne[4] followed by saying that climatically Siberia is not different from Alaska and the Klondike. Technically the Russian engineer is excellent, but some lack practice, which is true of other engineers. The Russian workmen are good enough when properly directed; and engineers must use diplomacy to succeed in any foreign country.

C. W. Purington, who knows Russia thoroughly, stated[5] that many persons appear to be under the delusion that the governmental fabric

[1] *Min. Sci. Press*, **122**, 391, 415, 457 (1921).
[2] *Min. Sci. Press*, **122**, 592 (1921).
[3] *Min. Sci. Press*, **122**, 806 (1921).
[4] *Min. Sci. Press*, **123**, 919 (1921).
[5] *Min. Sci. Press*, **124**, 79 (1922).

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of that empire has disappeared, but nothing could be further from the truth. The cloth is torn and rent in many places, but it is not destroyed. The communistic principle has always obtained in the Slav nature and mode of settlement, therefore this fact should not bring any cause for surprise.

Australia and New Zealand

Under the title of "Australian Mining Conditions, Peter G. Tait[1] of Melbourne discussed the past year's operations. The year 1921 was undoubtedly the worst ever experienced in the Commonwealth. High production costs, the arbitrary methods of adjusting wages, and the attitude of the labor unions, which failed to realize—because they did not want to—that war-time and peace-time conditions are altogether different, affected gold mining considerably. One outstanding result was the shutting-down of the Mt. Morgan copper-gold mine in Queensland, in May, 1921, because the men would not accept a reduction in wages to meet the low price of copper. Gold production of the six States fell off by at least 250,000 oz. during 1921, and had it not been for the Gold Producers' Association, which controlled the export and sale of new gold, few mines could have operated during the year. As it is, there is hardly a gold mine making a reasonable profit over and above the amount received as premium. From April, 1919, to December, 1921, the total premium received by all mines amounted to £3,246,171. The attitude of the unions is not entirely to blame, as, taking Kalgoorlie, in Western Australia, there is considerable room for improvement in the matter of power costs. A central station is needed, or else the companies should erect producer-gas plants and burn wood, of which there is an abundance, although it has to be railed 80 miles or more to the mines. The use of producer plants burning long lengths of wood is common in Australia, and they are guaranteed to consume only 2½ lb. of fuel per horsepower-hour against 8 to 24 lb. when used in a boiler furnace. Mr. Tait states that the Hampton Plains (Celebration) field, which was discovered in 1920, has failed to maintain interest.

In regard to the gold premium, it may be added that the average premium received during the period mentioned above was 5s. 8.84d., or 28.68 per cent. The expense in realizing this premium was 6d. (12 cts.) per pound sterling ($4.86).

Gold production of the Commonwealth of Australia and Dominion of New Zealand is shown by the following figures:

[1] *Eng. Min. Jour.*, 113, 289 (1922).

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PRODUCTION OF GOLD IN AUSTRALASIA, BY STATES
(In fine ounces)

State.	1914.	1915.	1916.	1917.	1918.	1919.	1920.	1921. (e)
New South Wales....	124,507	132,498	108,144	85,092	87,045	65,839	48,907	51,170
Northern Territory...	(e) 4,500	2,532	(e) 1,540	(e) 1,500	525	589	800	700
Papua (New Guinea).	.....	.....	.....	.....	8,707	11,919	11,000	11,000
Queensland.....	249,395	249,360	215,162	179,305	133,571	121,030	114,181	38,740
South Australia.....	6,258	6,081	7,769	7,145	6,189	3,224	1,697	3,600
Tasmania.....	26,243	18,547	15,790	14,496	10,529	7,686	6,246	6,000
Victoria.....	409,706	329,068	256,643	204,708	153,827	135,428	152,792	104,510
West Australia.....	1,232,974	1,210,109	1,061,398	970,317	876,510	734,066	617,842	553,730
Commonwealth.....	2,053,402	1,948,372	1,666,446	1,462,563	1,281,903	1,077,781	943,465	769,450
New Zealand.....	227,954	422,825	292,620	218,624	169,350	222,063	188,337	180,000
Total Australasia..	2,281,356	2,371,347	1,959,066	1,681,187	1,451,253	1,299,844	1,131,802	949,450

(e) Estimated.

Australia produced 8,326,000 oz. of silver during 1921, of which 2,711,729 oz. was exported as bars, ingots, etc., and 726,121 oz. exported in ore, concentrates, etc. The domestic consumption was 1,359,654 oz., largely for local coinage.

New South Wales.—The gold output showed an increase of 2266 oz. The State Department of Mines, through R. H. Cambage, forwards an instructive table on silver production from the mines of this State to the end of 1921, as follows:

Silver extracted in Australia, ounces	184,418,921
Silver in concentrates, etc., exported, ounces	180,436,699
Total silver, ounces	364,855,620
Value	£55,714,329

The yield of silver in 1921 was 4,241,890 oz.

Queensland.—The gold production of this State is just one-third of that in 1920, a condition largely due to the Mt. Morgan mine being closed from May, 1921, throughout the year, until March, 1922, by a miners' strike; also the closing of several copper mines on account of the market.

Victoria.—Production declined about 32 per cent. compared with 1920. There was nothing new to arrest this movement. Bendigo mines yielded 57,346 oz. of gold from 132,753 tons of ore, a decrease of 33 per cent. To this total the Bendigo Amalgamated contributed 32,091 oz. from 97,183 tons, a falling-off of 55 per cent. This company paid £75,951 in dividends.

Western Australia.—This once great producing State, and still the leader, registered a decline of 9 per cent. The Kalgurli mine, a large and profitable producer for 20 years, was sold to the Oroya Links Co., which wants the mill for custom ore treatment. The Sons of Gwalia had a large part of its plant burned, which affected returns somewhat. Late in the year there were good developments reported in the deep levels of the South Kalgurli, Lake View, and Ivanhoe; and

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prospects were encouraging at the North Kalgurli. Diamond-drilling a half-mile south of the Golden Horseshoe cut quartz-dolerite, but revealed no pay ore.

Regarding the Hampton Plains field, 20 miles south of Kalgoorlie, according to C. M. Harris[1] of Perth, developments during 1921 made the future more promising than they were when the Celebration mine encountered a low-grade zone on the 200-ft. level. Opening of the lode for 180 ft. at 300-ft. depth, all of which is payable, indicates possibilities at lower levels, which are to be opened as soon as milling commences.

The Celebration mill, consisting of 10 stamps, amalgamating pans, tube-mills, and continuous decantation slime plant, was expected to be ready by April, 1922. The whole of the power is generated by a suction gas plant, and costs should be low.

New Zealand.—Mining continued at about the same rate as in the previous year, but the producers suffered from lower premiums for their gold and lower prices for silver. The annual report of the Mines Department does not now give separate returns of gold and silver, but totals them as bullion exported, which is far from satisfactory for statistical purposes.

In the North Island, the Waihi Gold and Waihi Grand Junction were the largest among a few producers of gold and silver. Another geological survey of the Waihi field is under way, in charge of P. G. Morgan, the Government Geologist. A previous survey was made in 1912.

In the South Island there was a discovery of gold near Reefton, but enough work had not been done to estimate its possibilities. The Rimu dredge of the Kerr Lake Mining Co. of Ontario, Canada, started operating near Hokitika during October, and the first 25,000 cu. yd. of gravel yielded 9d. per yd., which bears out original sampling fairly closely. This is a 10-ft. dredge, and has 60,000,000 yd. to dig.

Metallurgy of Gold and Silver

A perusal of the matter appearing in this section of the chapter on gold and silver reveals particular interest being taken in the regeneration of cyanide and the effect of lead salts and lime in cyanidation; extension of the use of the vacuum precipitation process where zinc is used, and new proposals for utilizing charcoal as a precipitant; and the growing use of electric furnaces in melting precipitate or bullion. Under the caption of New Mills, some interesting departures from standard practice will be observed, notably the California Rand Silver mill, where the ore is to be concentrated by flotation; the use of rod-mills in the new Homestake mill; the elimination of flotation at the Arizona Silver Mines mill and

[1] Private communication, Jan., 1922.

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adoption of cyanidation; the remodeled mill of the Alaska Juneau, where 44 per cent. of the ore is discarded as waste, and where at present milling over 5000 tons daily only costs 30 cts. per ton; the effect of weathering the ore at the Globe and Phoenix mine; and recent innovations on the Rand, where all-sliming is to be the standard practice at the Springs Mines. Generally it will be found that there is more being done in gold and silver metallurgy than is suspected, especially in more or less radical departures from standard practice.

Chemistry

The beneficial action of lead salts in the cyanidation of gold ores was recognized early in the history of the process, and in 1893 J. S. MacArthur and C. J. Ellis obtained patents covering their use, according to R. W. Perry,[1] who discussed the value of these salts in treating silver ores. After covering theories and various experiments, Mr. Perry concluded by saying that lead salts have three distinct functions in cyaniding silver ores, as follows: (1) By aiding in the dissolving of silver through the replacement of the silver atom in silver sulphide by lead. (2) By being precipitated by various sulphides in preference to silver; the lead sulphide is inert toward silver. It is doubtful whether lead sulphide is always inert, as in contact with silver-cyanide solution without agitation it will produce some precipitation. (3) By being precipitated by some sulphides in preference to zinc, which sulphide is an active precipitant of silver.

There is little new to record regarding the use of the various brands of cyanide. Published as an advertisement,[2] a letter of A. S. Blomfield stated that the 30 to 45-per cent. cyanide, after a period of three years, had been found as active and effective on the 100-per cent. basis as any cyanide used in the Golden Cycle mill, Colorado Springs, Colo. The custom ores (from Cripple Creek) are roasted, and are probably more sensitive to trouble than raw ores. This cyanide is dissolved in a small agitator before being added to working solutions.

S. J. Kidder of the Mogollon Mines, New Mexico, stated, also in an advertisement,[3] that he used the low-grade cyanide for 11 months in 1921, and found that it had no bad effect on extraction.

Discussing the use of lime in cyanidation, Ernest Gayford[4] stated that certain tests, with small variations of lime, had a marked effect on the extraction of the gold. The ore assayed 1.2 oz. of gold, 1 oz. silver, 2.6 per cent. iron, and 92.4 per cent. insoluble,—a clean free-milling ore. In one instance a difference of only 1 lb. of lime per ton of ore raised the

[1] *Min. Sci. Press*, **122**, 221 (1921).
[2] *Min. Sci. Press*.
[3] *Min. & Met.*, March, 1922.
[4] *Min. Sci. Press*, **123**, 629 (1921).

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value of the tailing by $2.80 per ton in gold, the silver remaining constant. When 5 lb. was used the tailing increased to $11.40 per ton.

R. W. Perry[1] said that high lime consumption in cyanidation is often ascribed to the sulphates, soluble and insoluble, in the ore treated, oxidation products of sulphides being present in most cases, and also being produced to some extent during cyanidation. A case of high lime consumption came to Mr. Perry's notice where there were practically no sulphides or sulphates present, and it was found that ferrous carbonate was present in appreciable quantities, and was being oxidized during treatment to ferric hydrate, or possibly to hydrated ferric oxide. This oxidation was accompanied by a corresponding precipitation of calcium carbonate if sufficient lime was present, the iron otherwise combining with the cyanide to form sodium ferrocyanide. The consumption of lime might be decreased by shortening the period of treatment, if possible.

In discussing lime in cyanidation, W. W. Emminger[2] stated that in treating oxidized ores from the Rochester Silver Corporation's mines in Nevada the consumption of lime was 10 lb. per ton of ore. From 80 to 85 per cent. of the silver was recovered by simple all-sliming treatment, but one block of ore assaying 30 to 34 oz. of silver and 0.10 oz. of gold yielded only 35 per cent. As the ore contained antimony—as a silver mineral—it was assumed that a large percentage of the silver was combined therewith. All manner of experiments were made to improve the recovery, and on using from 60 to 130 lb. of lime per ton of ore the extraction increased from 61 to 92 per cent. This was very expensive, so an attempt was made to reduce the lime by agitating in colder cyanide solutions. A temperature of 60° F. gave a 70-per cent. recovery, whereas 120° gave 90 to 94 per cent. The heat was increased to 140°, but only decreased the time-factor. Cyanide consumption increased as the extraction increased—at 35 per cent. it was 1 lb. per ton of ore; at 90 per cent. it was 3 lb. The amount of lime required decreased as the silver content of the ore decreased. The gold extraction remained the same—90 per cent.—whether 10 or 130 lb. of lime was used. So much lime affected precipitation, and a white precipitate was deposited everywhere.

At a 50-stamp mill at Taiyudong in Korea, according to C. Flury,[3] the pulp was classified into sand and slime, but as the leaching plant was too small for a recent addition of 20 stamps, 10 Wilfley tables were installed to concentrate the sand. Previously, a 12-day treatment of the sand, with transferring twice to another vat, gave an extraction of 80 per cent. In treating the concentrate, 16 days was given with three

[1] *Min. Sci. Press*, **122**, 605 (1921).
[2] *Min. Sci. Press*, **124**, 44 (1922).
[3] *Min. Sci. Press*, **123**, 771 (1921).

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transfers, and the extraction improved to 86.5 per cent., with the same strength of solution, etc. It was deduced from this result that the longer time was not responsible but the physical character of the sand was changed and improved by concentration.

The consumption of zinc in the cyanide plants of the Rand totals 5,000,000 lb. per annum, and the major portion of this is said[1] to be recoverable by the Kominsky process, now being tested at Germiston, east of Johannesburg. The object of this process is to recover in pigment form the zinc in the waste liquor from acid treatment of the zinc-gold precipitate. On an average this liquor carries zinc salts equivalent to 5 per cent. of metallic zinc, plus a little iron salts mostly in the ferrous condition. The acidity of the liquor is first reduced to a suitable point, when the iron is converted to the ferric state by adding sodium chromate. Caustic soda is added to a portion of the original liquor, precipitating impure zinc hydroxide, which is made into a thin paste and added in excess to the fully oxidized liquor. The first action is that of the excess of acid present on the suspended zinc hydroxide, whereby the solution is neutralized and a quantity of zinc sulphate equivalent to the free sulphuric acid present is produced and passes into solution. The zinc hydroxide then reacts in the neutral solution with the ferric and chromium sulphates, producing insoluble ferric and chromium hydroxides, which separate from the solution and an equivalent quantity of zinc sulphate passes into solution. The fluid is then filtered, and the clear filtrate obtained is a neutral solution of zinc sulphate and sodium sulphate. The sludge in the filter-press contains an excess of zinc hydroxide mixed with hydroxides of iron and chromium, and can be re-used as a precipitating agent until the zinc hydroxide is almost exhausted. The clarified solution carrying zinc and sodium sulphates is now ready to be precipitated, which may be effected by means of a solution of sodium carbonate, in which case insoluble zinc chromate separates. The insoluble zinc salt is well washed with water to remove all the sodium salts, and is then separated in a filter-press. The sludge in the press is then dried, in a dust-proof drier. The dried zinc chromate only requires to be crushed and screened to be ready for use as a pigment—zinc yellow. To make zinc white (zinc oxide) the dried basic carbonate would have to be calcined in a furnace, and to make a satisfactory pigment the calcined material must be finely ground and screened. On the basis of a waste liquor carrying 5 per cent. metallic zinc, each gallon would contain ½ lb. of zinc, and from this would be obtained 1.38 lb. of zinc chromate (zinc yellow) with the aid of 1.25 lb. of sodium carbonate; or, if zinc white were made, the yield would be 0.62 lb.

[1] *So. Afr. Jour. Industries*, Dec., 1921.

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According to A. F. Crosse in his "The Beginning of the Cyanide Process on the Rand,"[1] the start was at the wrong end, namely, an attempt to treat a comparatively coarse concentrate assaying 5 to 6 oz. of gold per ton in a strong cyanide solution. That was in 1891. Mr. Crosse then discussed amalgamating gold, fine grinding, alkalinity and oxygen in cyanide solutions, and the use of hypochlorite of lime.

Under the title of "Cyanide Notes,"[2] Algernon Del Mar discussed factors in zinc-dust precipitation and the apparent regeneration of cyanide during that process. In a mill in Mexico, treating 8-oz. silver ore, and precipitating on zinc dust, in one month 3000 tons of solution titrated 0.68 lb. of cyanide per ton before precipitation and 1.0 lb. after. This represented a regeneration of 960 lb. of cyanide during the period. The consumption of cyanide was 1.38 lb. per ton of ore, and the regenerated cyanide represented 0.32 lb. per ton of ore treated. The average lime content at all times was 0.14 lb. per ton of solution. Mr. Del Mar concluded (1) that regeneration is due to the lime present forming zinc hydrate, liberating cyanide; (2) that regeneration increases as the precipitation of basic zinc carbonate increases; and (3) that the addition of sodium carbonate to the sumps has a beneficial effect on precipitation. He also considered that a zinc-dust precipitating system should embody the following: (1) The zinc dust must be kept from contact with air; (2) the dust should not be allowed to form lumps; (3) the distance from the zinc intake to the filter-press should be short; (4) the press should always be kept full of solution; (5) there should be an automatic feeder to deliver the right amount of zinc for complete precipitation, but with no excess of zinc; (6) there should be a means of measuring the amount of solution precipitated; and (7) the solutions precipitated should be regularly titrated and assayed.

A. W. Allen[3] followed Mr. Del Mar, and said definitely that the ordinary test as a means of estimating free cyanide was inaccurate, and no appreciable amount of free cyanide can be regenerated during the precipitation of gold and silver by zinc; and the apparent increase in cyanide is due to the higher alkalinity resulting from the precipitation of the metal and the dissolution of zinc, as shown by the following equations:

$$KAg(CN)_2 + 2KCN + Zn + H_2O = K_2Zn(CN)_4 + Ag + H + KOH$$

$$Zn + 4KCN + 2H_2O = K_2Zn(CN)_4 + 2KOH + H_2$$

and the action of the silver nitrate on the double cyanide, in the presence of this additional alkali, thus:

$$K_2Zn(CN)_4 + 4KOH + 2AgNO_3 = 2KAg(CN)_2 + Zn(OK)_2 + 2KNO_3 + 2H_2O.$$

[1] *So. Afr. Min. Eng. Jour.*, **32**, 1331 (1921); abst., *Min. Sci. Press*, **123**, 405 (1921).
[2] *Min. Sci. Press*, **122**, 810 (1921).
[3] *Min. Sci. Press*, **122**, 870 (1921).

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C. Flury,[1] referring to Mr. Del Mar's statement that the regeneration of cyanide increases as the precipitation of basic zinc carbonate increases, thought that it would be difficult to precipitate the zinc salt in the presence of soluble lime salts, on account of the affinity of calcium for carbon dioxide. Precipitation of carbonate of lime would occur first, and before zinc cyanide is converted into basic carbonate. He could see no connection between the regeneration of cyanide and an increase in basic zinc carbonate, deducing this from a number of equations presented.

Alfred James[2] followed by saying that the apparent regeneration is likely to arise from the absence of a satisfactory test. The presence of alkali or alkaline carbonates, always present in used solutions, interferes with the silver-nitrate test, making the solution appear stronger in available cyanide than is really the case. Chemists should, therefore, be careful not to be misled by this test, or lowered extraction may result. The effect of caustic potash or soda on double cyanide of zinc and potassium is *not* to regenerate all the cyanide of potassium as shown by the silver test.

E. M. Hamilton[3] thought that the issue was obscured by the failure to distinguish between free and total cyanide; and while some of the free cyanide consumed in dissolving silver in an ore may later on be rendered available for further use through the indirect action of zinc precipitation, yet such regeneration does not take place in the act of precipitation, but is a secondary result produced in the previously precipitated solution by contact with alkalies or other substances.

Further contributions on this topic were offered by Chas. Lintecum, J. E. White, and H. R. Layng.[4] The last named (since deceased) stated that he had studied cyanide regeneration during three years, and made over a thousand tests—large and small—and all indicated that acid regeneration is practicable, and could be conducted in many cases at considerable profit.

Additional information on the metallurgy of carbonaceous gold ores was given in the paper by Andre Dorfman,[5] who said that during September, 1914, the residue from the Porcupine Crown mill, apparently without any reason, showed considerable increase in value. The average extraction had previously been 95 per cent. The cause of this low recovery was soon traced to graphitic schist, a sample of which was examined. On bringing the pulverized schist into contact with a gold-bearing cyanide solution it was found that the mineral acted as a powerful precipitant. Precipitation tests were then carried out by percolation

[1] *Min. Sci. Press*, **123**, 918 (1921).
[2] *Min. Sci. Press*, **123**, 225 (1921).
[3] *Min. Sci. Press*, **123**, 81 (1921).
[4] *Min. Sci. Press*, **124**, 218, 394, 358 (1922).
[5] *Bull. Can. Inst. Min. Met.*, March, 1922, p. 383.

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and agitation on crude and roasted samples, all reduced to pass 100 mesh. The solution carried $2.64 gold per ton, and a percolation test on a crude sample showed that of 500 c.c. of solution, the first four 100 c.c. assayed $0.012 per ton, but the fifth 100 c.c. assayed $0.036. A percolation test on a roasted sample showed that no gold was precipitated. The raw sample, when agitated with a pregnant gold solution, acted as a precipitant almost at once; the roasted sample, however, lost all its precipitating power.

As the result of his further experimentation, Mr. Dorfman stated that the amount of gold precipitated by carbonaceous schist from a sodium auro-cyanide solution ($NaAu(CN)_2$) appears to be in direct proportion to the quantity of carbon present in the graphitic schist. It was found that there was a permanent loss of $2 of gold for each pound of carbon in the schist. This particular schist carried 5 per cent. of carbon. To overcome this objectionable behavior, experiments were made along the following lines: (1) Chemical pre-treatment of the ore; (2) chemical after-treatment of the mill tailing; (3) physical methods—vacuum and heat; and (4) flotation concentration. It was finally found that by pre-treating the ore containing graphitic schist with approximately ¾ gal. per ton of a mixture of crude, fuel, and gas oil, the precipitating properties of the schist were neutralized and destroyed, and a high extraction of the gold was secured.

Amalgamation

Millmen should find interest in the discussion[1] entitled "Wetting and Amalgamation" contributed by S. H. Dolbear, A. W. Allen, F. H. Mason, M. W. von Bernewitz, and T. T. Read. The question arose as to the analogy between the action of quicksilver on gold and oil on mineral particles. The consensus of opinion was against any analogy, and some interesting points were elicited concerning how mercury acts on gold.

Grinding

Metallurgists who may be perplexed regarding the advisability of installing a grinding machine, which one is best or what should be the cost of grinding, will find the article[2] of Harlowe Hardinge, discussed under Ore Dressing in another part of this volume, a concise statement.

The decision of the Consolidated Mines Selection Co., which controls the Springs Mines company in the Far East Rand, in enlarging the reduction plant at the Springs mine to discard stamping and plate amalgamation and adopt all-sliming and direct cyanide treatment, started G. A.

[1] *Min. Sci. Press*, **123**, 665, 699, 772, 881, 919 (1921); **124**, 113, 324 (1922)
[2] *Chem. Met. Eng.*, **25**, 229 (1921).

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and H. S. Denny in a series[1] of articles on new developments in ore treatment on the Rand. Present methods are well understood, and the all-sliming process would eliminate stamps, amalgamation, and separate treatment of sand and slime. There would be substituted machinery for finer crushing and grinding to pass 125 to 200 mesh, and circulation of cyanide solution through the whole operation from the tube-mills down. It is deduced that there would be a substantial reduction in capital expenditure and operating costs, increased extraction, improved control of operations, and safety from theft of gold. Messrs. Denny also discussed the present methods and efficiency of crushing Rand ore, tube-milling, amalgamation, etc., and are continuing the series of articles.

The "new metallurgy," as it has been termed, was concisely explained in an editorial,[2] wherein it was stated that the underlying idea is elimination of the stamp as a crusher. The flow-sheet will have as its main essentials crushers, tube-mills, and filter-presses. The stamp and sand-leaching plant will be superseded by an all-sliming process. A saving of 30 per cent. in capital cost is anticipated, also less operating charges and lower residues.

In answer to the Editor's query concerning the subject of all-sliming on the Rand, Alfred James[3] said that when in spite of the high level to which stamp-milling had attained on the Rand, the question should once more have arisen of the abandonment of stamps and the adoption of all-sliming, there must be a new factor there to account for this resurrection of the earlier proposals. This new factor must be a change in the character of the ore; or in other words, that the ore of the Far East Rand requires finer comminution for effective beneficiation than the more porous mineral of the Central Rand. Even so, the problem would appear to be simple of solution: (1) The cost of sliming the proportion of total ore, say 40 per cent., at present treated as sand; this cost was recently reported to be 1s. 9d. (42 cts.) per ton actually slimed; (2) the added cost of the necessary equipment; and (3) the increased gain resulting from all-sliming. Former investigations showed that the increased recovery obtained failed to compensate for the extra cost of sliming. With the ore of the Far East Rand the position may be reversed, but one cannot base figures on the difference between the recovery at present being obtained from sand and the increased recovery at present being obtained from slime. Mr. James' experience found that reduction of clean quartz particles of sand to slime by no means yields the same recovery as that obtained from the, what he termed, natural slime, of an ore, the softer vein material, which may be clay, decomposed iron, and pyrite.

[1] *Min. Jour.*, **135**, 722, 758, 796, 866 (1921); **136**, 4 (1922), and others following.
[2] *So. Afr. Min. Eng. Jour.*, **32**, 1375 (1921).
[3] *Mining Mag.*, Jan., 1922, p. 24.

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Flotation

The design of flotation plants was the subject of a paper by A. B. Parsons,[1] and flow-sheets were given among others showing the method of treatment at the Smuggler Union silver-gold-lead-copper-zinc mine at Telluride, Colo.; and the new mill at the Boston & Montana silver-copper mine at Wise River, Mont. The concentrate in each case is shipped for further treatment.

Precipitation

According to C. W. Merrill,[2] the two largest cyanide plants to be built during 1922 will be the mills of the New State Areas, Ltd., in the Transvaal, and of the United Comstock Mines on the old Comstock lode in Nevada. Both plants will have initial capacities of 50,000 tons of ore per month, and both will precipitate with the Merrill and Crowe processes. The Merrill company states that it was able to promise the metallurgists of these companies the following definite results: (1) A zinc consumption of 0.05 lb. per ton of gold solution precipitated and correspondingly low on the silver ore; (2) complete elimination of white precipitate; (3) direct melting of raw precipitate without acid treatment; and (4) uniformly low barren solution, and no bullion continuously locked up in zinc-boxes.

Zinc dust has received much investigation by American metallurgists, but the paper[3] by Oystein Ravner, of the Institute of Inorganic and Physical Chemistry, Technical High School of Norway, will be found of interest. Included is a complete chemical analysis of zinc dust from retorts and electric furnaces. There is much more sulphur and oxide in zinc dust from electric furnaces than in the retort product. This is due to the fact that electric furnaces reduce ores higher in sulphur. Specific-gravity determinations and briquetting experiments were made.

An American patent for the use of charcoal in the precipitation of gold from cyanide solutions was granted during 1921 to K. B. Moore and H. R. Edmands of Australia, and A. W. Allen[4] discussed historically the use of charcoal as being one of the most interesting developments in the history of cyanidation. Lump charcoal was first used, and no improvement was made in the method for 20 years, until the above-mentioned metallurgists in 1917 found out that fine charcoal was much better than the lump material, and have since applied it successfully in Western Australia and Rhodesia. Red-hot charcoal from a producer-gas generator is allowed to drop into water, is pulverized in a ball-mill, mixed with

[1] *Min. Sci. Press*, 123, 775 (1921)
[2] *Eng. Min Jour.*, 113 40 (adv.) (1922).
[3] *Tidsskrift for Bergvaesen*, No. 11, 138 (1919); *Chem Met, Eng* ., 24, 932 (1921).
[4] *Min. Sci. Press*, 123, 493 (1921).

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the auro-cyanide solution, and cakes are formed on a leaf-filter. After a definite period these are discharged, re-pulped, and re-formed on the filter. The extractors operate in series, the one in which the cakes are approaching saturation receive the richest solution, the tailing solution going to a second extractor being finally impoverished by contact with fresh charcoal. The final cake, loaded with gold, is filter-pressed, dried, and melted. A tilting furnace has been found suitable. The reason why producer-gas charcoal is used is because the theory is held that precipitation is due to occluded carbon-monoxide gas. Mr. Allen concluded by saying that the adoption of charcoal as a precipitant, if practicable, would obviate all difficulties arising from fouling of solutions or incrustation of equipment, since the action is a physical one, and no deleterious compounds are formed.

The subject was briefly discussed by William Motherwell,[1] who has worked with charcoal as a precipitant in Victoria, Australia, and New Zealand, and favors its use.

The principal points of interest in "Recent Metallurgical Practice on the Rand"[2] were the fact that the ores of the Far East Rand are materially different from those of the Central and West Rand, in that the pyrite is more compact and more finely disseminated; and that the Crowe vacuum process of precipitation has been successfully introduced. The percentage of gold saved by amalgamation has decreased from 70 to 35, and on account of finer grinding necessary, only about 25 or 30 per cent. of the pulp can be leached as sand; all-sliming treatment seems to be obvious. Up to 1921, the objection to precipitating on zinc dust was the fact that solutions from treating slime were extremely low in cyanide and alkali content, hence zinc shavings coated with lead acetate gave effective precipitation; but as the Crowe process removes the dissolved oxygen from the solutions, precipitation becomes practically independent of alkalinity and cyanide strength.

In giving detailed milling costs at Las Dos Estrellas, Michioacan, Mexico, T. S. Saunders[3] pointed out that the economy effected by zinc dust plus the Crowe vacuum system over zinc-thread precipitation amounted to 29 centavos (14.5 cts.) per ton of ore treated during 1919, and somewhat in excess of this in 1920. The actual cost of precipitation in 1919 was 34 centavos (17 cts.) and 14 centavos (7 cts.) in 1920. During these two periods, 361,878 and 366,821 tons, respectively, were treated at a total cost of 3.203 pesos ($1.60) and 3.051 pesos ($1.52) per ton.

Precipitation and refining methods, as practiced at three of the cyan-

[1] *Min. Sci. Press*, **122**, 600 (1921).
[2] *Eng. Min. Jour.*, **111**, 623 (1921).
[3] *Eng. Min. Jour.*, **111**, 578 (1921).

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ide plants in the Tonopah, Nev., district, were concisely covered by F. C. Ninnis[1] and W. W. Anderson, and may be shown in tabulated form as follows:

	Belmont.	Extension.	West End.
Silver content of ore, ounces	11.81	12.27	19.73
Method of clarifying pregnant solutions.	Merrill presses	Excelsior in first two compartments of zinc-boxes	Excelsior in a tank
Precipitating agent	Zinc dust	Zinc shavings	Zinc shavings
Silver content of effluent solution, ounces	0.01 to 0.02	0.05 to 0.25	0.02 to 0.12
Solution precipitated for each ton of ore, tons	4.5	3.4	.....
Zinc consumption, troy ounces per fine ounce of bullion	0.65	0.87	0.77
Clean-up	Monthly	Bi-weekly	Weekly
Moisture in precipitate before adding fluxes, per cent	16.0	6.0	15.0
Fluxes:			
Borax, per cent	3.0	10.0	.....
Soda, per cent	8.0	8.5	.....
Sand, per cent	.....	5.0	.....
Furnaces used	Monarch-Rockwell	Monarch-Rockwell	Monarch-Rockwell
Lining	Carborundum or	silica brick with car	borundum behind
Life of lining, ounces of bullion	642,000	500,000	620,000
Best melt	59,700 ounces in 17 hours		

MELTING

Among the papers of the symposium on non-ferrous electrometallurgy at the 40th general meeting of the American Electrochemical Society in September was one entitled "Electric Silver Melting," by H. A. DeFries. This created a great deal of attention and gave rise to lengthy discussions. By this process, the high cost of graphite crucibles is eliminated, also the need for an experienced melter, which are essential to gas or oil-fired crucible practice. Distinction was made between the pouring temperatures of bar silver (1038 to 1093° C.) and of rolling-mill and casting silver (1293 to 1304° C.), when casting horizontal molds. G. B. Hogaboom emphasized the importance of a high pouring temperature, which can be so readily attained in the electric furnace. E. F. Northrup of Trenton, N. J., reported that over 1,000,000 oz. of silver had been melted in his electric furnace.

Mr. DeFries also had a paper published[2] under the caption "Melting Fine and Sterling Silver by Electricity." Great care must be exercised in handling molten silver between a furnace and molds, as a difference of only 100° C. will produce crystallization, with attending brittleness. During melting, the silver should not be disturbed by stirring or rocking, as the protective cover formed, which protects this metal from gases, if broken, would allow the oxygen in the gases and air to be absorbed by the metal. An absolute oxygen control is possible in the electric furnace, but

[1] *Min. & Met.*, No. 172, 25 (1921).
[2] *Chem. Met. Eng.*, **25**, 507 (1921).

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not in an oil-fired furnace. An almost neutral atmosphere, slightly reducing, is found most suitable, and can be easily obtained in an arc furnace. If a more reducing atmosphere is required, 1 lb. of powdered charcoal to 5000 oz. of molten silver is effective. The furnace should be air-tight, and pouring should be done through a special tap-hole. The travel from spout to mold should be as short as possible. Molds are best smoked and heated to 205° C. Only two types of electric furnaces can be considered, namely, the indirect-arc furnace of the stationary type, and an induction furnace, such as the Ajax-Northrup. The latter possesses greater adaptability to this particular work. Mr. DeFries used a furnace of the Rennerfelt type, of 10,000-oz. capacity. The aver-

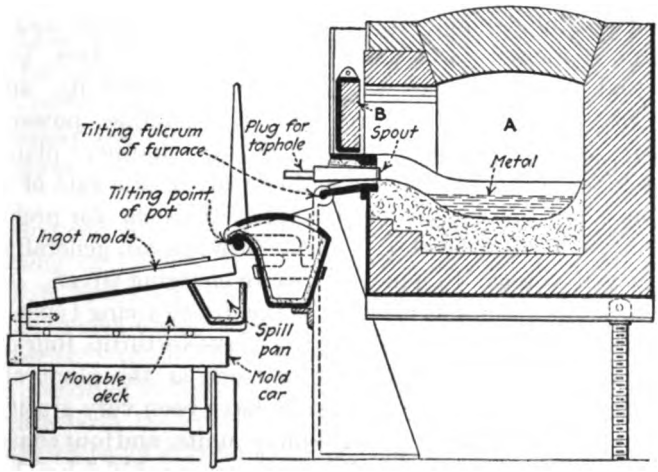

FIG. 4.—Construction of silver-melting outfit.

age charge was 4000 oz., and power consumption 330 kw.-hr. per ton (30,000 oz.) of silver. The Ajax-Northrup furnace uses 320 kw.-hr. Lining for the indirect-arc furnace should be either of silica brick or firebrick, with a hearth of ganister or carborundum, which is wetted with sodium silicate, rammed well, and thoroughly sintered with the arc. Such a lining will last indefinitely. Not more than 5 oz. per 10,000 oz. melted should be lost. Electrode consumption will average 5 lb. per ton of metal. The furnace will produce 60,000 oz. in 8 hr. at a total cost of 77 cts. per 1000 oz. The above sketch shows the construction of an efficient electric silver-melting plant. This furnace tilts. In comparing electric and crucible silver it is found that the former has a much finer grain, is easier to roll, stamps perfectly, gives 85 per cent. better forgings, and is 100 per cent. perfect in spinning (against failure for crucible silver).

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In his paper[1] on electric furnaces for silver, gold, and metals of low melting point, Jonas Herlenius said that the electric furnace has the following main advantages over fuel-heated furnaces: (1) A more perfect temperature control; (2) less loss by oxidation through a neutral or reducing atmosphere; and (3) higher efficiency. He then discussed six types of electric furnaces, but eliminated the direct-arcing type, which causes an excessive loss by volatilization. The melting point of silver is 960° C., and its boiling point 1950° C., and the pouring temperature should be about 1295 to 1305° C. Accurate temperature control is necessary. Any chilling results in brittleness. The furnace must be air-tight, should have suitable working doors, and should be of the tilting type for quick pouring. The Rennerfelt free-burning arc furnace, as used at the Philadelphia Mint, is of 1000-lb. capacity, and during one campaign re-melted 3,142,000 lb. of silver dollars into bullion. The actual melting time was 50 min. for 1000 lb., and the loss was 2 oz. per 10,000 oz. melted. The average power consumed was 177 kw.-hr. per ton of metal. At another plant a 500-lb. Rennerfelt furnace melts sterling and fine silver, at a rate of one heat an hour, consuming 250 kw.-hr. per ton, plus 80 kw.-hr. for preheating, and loses 4 oz. per heat of 5000 oz. These furnaces are generally preheated to a light yellow incandescent heat before charging silver. The carbon-resistor furnaces are not as efficient as the direct-arcing types. The only high-frequency induction furnace is the Ajax-Northrup, four of which are operated at the Philadelphia Mint and one at the plant of Handy & Harmon at Bridgeport, Conn. Results have been very gratifying. The Mint furnaces are stationary, single-phase units, and four charges totaling 13,490 oz. have been melted in 7 hr., consuming 156.5 kw.-hr. The H. & H. furnace, of 600 lb. capacity, reduced 36,558 oz. in 8¼ hr., using 317 kw.-hr., including preheating. The Ajax-Northrup type shows high efficiency, and will be found best for melting silver on a medium scale. This furnace is also well suited for gold, which should be melted in crucibles on account of its high value.

The Ajax-Northrup furnace mentioned above was described[2] by E. F. Northrup, who considers that it is virtually an electric crucible. The furnace is a practical combination of crucible-melting flexibility with the advanced practice of electric melting. Later,[3] the same writer gave a resumé of recent progress in high-frequency inductive heating, with special reference to electric furnaces for melting precious metals, including those at the Philadelphia Mint and at Handy & Harmon's refinery. There is no doubt as to their success.

[1] *Chem. Met. Eng.*, **25**, 454 (1921).
[2] *Chem. Met. Eng.*, **24**, 309 (1921).
[3] *Chem. Met. Eng.*, **24**, 1097 (1921).

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In his paper "Gas Furnaces for Melting Non-ferrous Metals," M. A. Combs[1] considers that the gas furnace has the lowest operating cost and is very flexible. While this paper dealt with the melting of alloys, gold and silver metallurgists should find some points of value in it. Tilting or pit types may be used. Gas is free from sulphur, while oil is not. At present, oil is equal to, if not more expensive, than gas in fuel cost alone. Gas need not be stored like oil, but used direct from pipes. A gas furnace is considered to be more flexible than an electric furnace. Less space is occupied than by a pot furnace, and while the latter will give two or three heats a day, a gas furnace will give eight. A properly designed gas furnace has an interior diameter just large enough to admit the tongs when lifting out the crucible. Long runs with coal, oil, and gas furnaces showed that gas was by far the most economical and satisfactory fuel.

E. L. Crosby followed[2] Mr. Combs by disputing the latter's claims, especially regarding electric furnaces, which Mr. Crosby favors, and gave figures much lower for such furnaces than those given for gas furnaces.

The dusting and volatilization losses while melting cyanide precipitate and air-refining of bullion was investigated and discussed[3] by G. H. Clevenger, F. S. Mulock, and G. W. Harris of the U. S. Smelting, Refining & Mining Co., which operates the largest silver producer in the world at Pachuca, Mexico. In converting precipitate into bullion there may be losses while handling it before it reaches the melting furnace, also after the precipitate is in the furnace. The precipitate from the two mills contains from 75 to 78 and 80 to 85 per cent. of silver and gold, in the ratio of 165 to 1. Precipitation is effected by means of zinc dust. Melting is done in two crude-oil fired reverberatory furnaces with firebrick bottoms, having hearth areas of 25 and 49 sq. ft. Fluxes used are borax glass and finely ground bottle glass. Some special apparatus was used for the determinations. The average loss of silver and gold was 0.1074 and 0.02805 per cent. in one case, and 0.0625 and 0.0150 per cent. in the other, when melting precipitate; while during the air-refining of the two lots of bullion the losses were 0.0497 per cent. of the silver and 0.0133 per cent. of the gold, and 0.0156 and 0.00387 per cent., respectively. The experiments demonstrated that there would be no difficulty in eliminating by simple air-refining, without the use of fluxes, practically all of the base metals excepting copper.

Parting doré bullion (silver and gold) at the refinery of the Bunker Hill & Sullivan smelter at Kellogg, Idaho, was described by T. A. Rick-

[1] *Chem. Met. Eng.*, **24**, 515 (1921).
[2] *Chem. Met. Eng.*, **24**, 912 (1921).
[3] *Min. & Met.*, No. 181, 11 (1922).

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ard.[1] This bullion is the result of cupelling lead. The 500-oz. bars of doré bullion, in charges of 10,000 oz., are parted in cast-iron kettles by means of 66° Bé. sulphuric acid. The silver is dissolved, and the resulting silver-sulphate solution is drawn into lead-lined vats. Copper bars are suspended in these vats by means of "corrosiron" hooks, and steam is introduced to make the solution boil. The silver is precipitated on the copper, which in turn goes into solution as sulphate. The silver is deposited as cement silver, which is filtered, washed in boiling water, dried, and melted in a Monarch double-chamber oil-fired tilting furnace. The resulting silver is 999 fine. For 1000 oz. of silver produced, 125 lb. of acid and 21 lb. of copper are used. The insoluble residue in the kettle contains the gold in the form of a brown powder. It is boiled to remove any sulphates, then melted in a graphite crucible. The copper solution is partly evaporated to cause the copper sulphate to crystallize, and the crystals are re-dissolved in water and again crystallized on strips of lead in another lead-lined vat, and is then ready for the market—to be used in flotation mills using a selective process, or for spraying trees.

New Mills and General Construction

The 100-ton mill of the California Rand Silver company, recently built at Randsburg, San Bernardino County, southern California, is attracting considerable attention, and the metallurgy of the ore was discussed by A. B. Parsons.[1] To December, 1921, a total of 30,130 tons of ore sent to smelters returned $2,101,394 silver and $127,061 gold, net value. Some of this ore contained 80 per cent. silica, nearly 5 per cent. each of iron and sulphur, 1 per cent. arsenic, 0.5 per cent. antimony, and was high in silver, with a little gold. Of the 100,000 tons of $20 ore estimated as reserves, 10,000 tons is oxidized. The silver minerals in the sulphide ore are argentite, pyrargyrite, proustite, and stephanite. There is some iron pyrite, with which the gold is associated. Five well-known metallurgical firms made tests on the ore to devise a flow-sheet for treatment. Messrs. Hamilton, Beauchamp and Woodworth tried eight distinct processes or combinations of processes, and that of straight or "bulk" flotation of the entire feed, as shown in Figure 5, was decided upon. A recovery of 96.65 per cent. is anticipated. There was little difference between the expected results from this process and selective flotation, and tabling and flotation. The ore tested assayed 28.25 oz. of silver and $3.10 gold per ton, and the concentrate carried 200.16 oz. of silver and $23.56 gold. A license contract for using flotation was signed with Minerals Separation, the royalty being either a flat rate of 2½ per cent. on the value of the ore treated, or 5 cts. per ounce of silver and 50

[1] *Min. Sci. Press*, **122**, 58 (1921).
[2] *Min. Sci. Press*, **124**, 11 (1922).

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cts. per ounce of gold recovered from any portion of the ore that might be treated by flotation—a high royalty. As the marketing of 200-oz. silver concentrate is very expensive—about $55 per ton, freight alone being over $15 per ton—the cheapest shipping product is bullion, so that eventually the concentrate will be either smelted locally or treated by chloride volatilization.

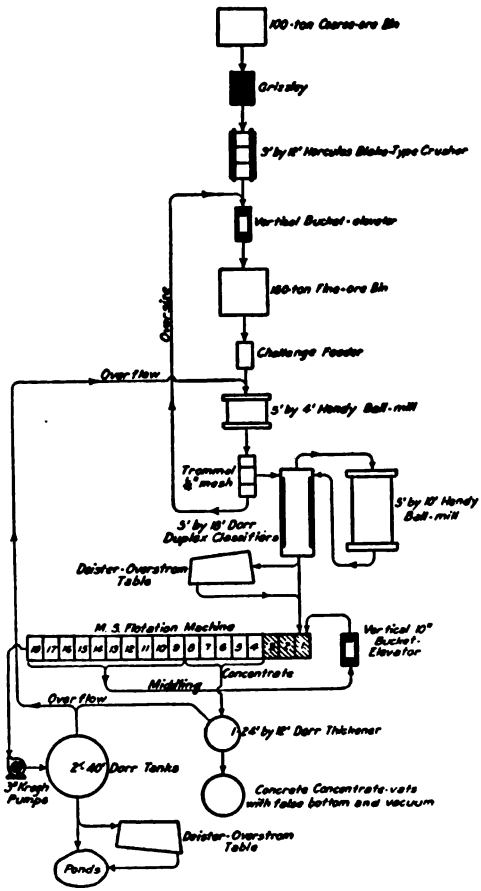

FIG. 5.—Flow-sheet of the California Rand Silver mill, which started in December, 1921.

After studying Mr. Parsons' paper on treatment at the Kelly mine, H. R. Layng[1] asked why, when chloridizing volatilization would produce (assumed) better results on the raw ore than on the concentrate, precede chloridizing volatilization by a more costly and less efficient process (flotation) when chloridizing volatilization alone is probably able to

[1] *Min. Sci. Press*, **124**, 84 (1922).

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accomplish at least the same result as the two processes at less cost? Mr. Layng then said that a 100-ton chloridizing volatilization plant using his process would cost less to install and operate than the flotation plant, with at least 95 per cent. extraction.

According to the annual report of W. P. Robertson, Provincial Mineralogist of British Columbia, the Premier mine in the Salmon River dis-

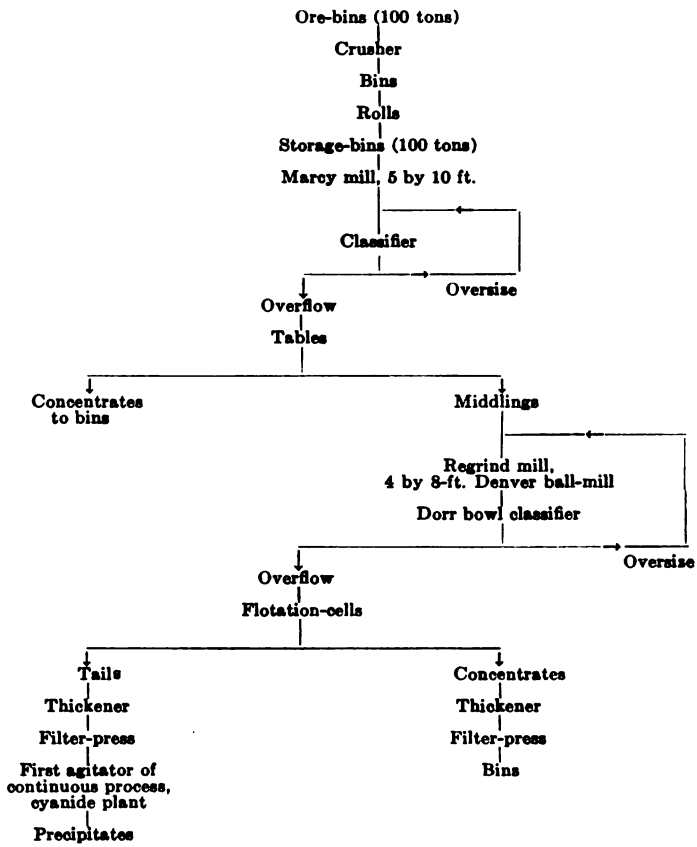

FIG. 6.—Flow-sheet of Premier mill, Salmon River, Portland Canal, British Columbia.

trict in 1921 shipped 4356 tons of ore, also 1000 tons of concentrates and 9000 lb. of precipitates from the new mill and cyanide plant, which started operations in July. The total output was 35,000 oz. of gold and 1,200,000 oz. of silver, worth $1,400,000. The mill was designed for 100 tons daily capacity, but it has been working at over capacity, producing form 20 to 30 tons of concentrates daily. Figure 6 shows the present flow-sheet of the mill.

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The Arizona silver mine, near the old Unionville district of Nevada, and 30 miles from Mill City on the Southern Pacific, produced rich ore in the early days, and then remained idle until 1912, when a modern mill was erected but failed to treat the ore successfully, according to F. Borzynski.[1] A few years later the property was acquired by the Sunset Mining & Development Co., which erected a flotation plant. This was a success, but the marketing of a large quantity of comparatively low-grade concentrate was expensive, so it was decided to concentrate the ore

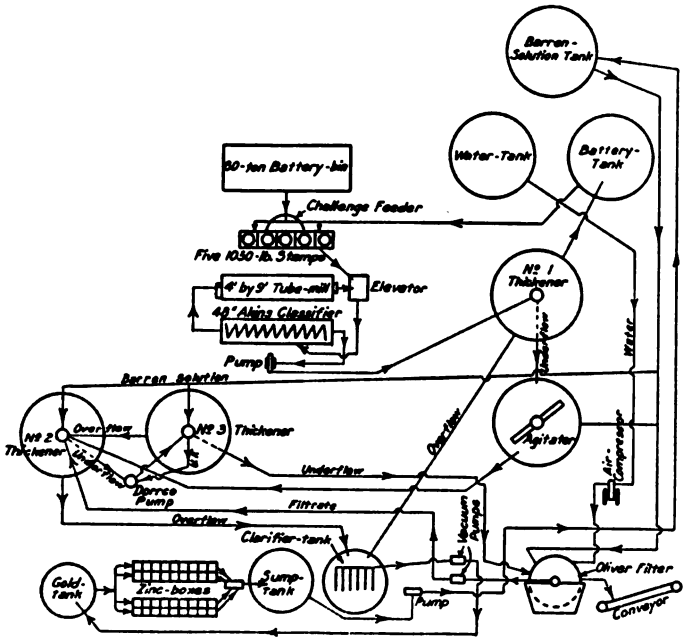

FIG. 7.—Flow-sheet of Arizona silver mill, Nevada.

roughly by means of vanners and K. & K. flotation machines, and cyanide the tailing. The new plant started in October, 1921, but flotation and then the vanners were discarded, and the process finally adopted is that shown in Fig. 7. The ore consists of quartz and lime carbonate, with small quantities of pyrite, stibnite, and sometimes scheelite. The limestone is very calcareous, containing a considerable amount of oil. Argentite is the principal silver mineral, with a little bromide and chloride. The ore shatters easily, and more than 60 per cent. will pass a 4-mesh screen as the ore comes from underground. Flotation before cyanidation is unnecessary. The consumption of cyanide is 2.7 lb., lime 1.5 lb.,

[1] *Min. Sci. Press*, **122**, 717 (1921).

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and lead acetate 0.3 lb. per ton of ore treated; by careful proportioning of these chemicals the oil in the ore is rendered comparatively harmless.

The accompanying section (Fig. 8) is that of the new South mill of the Homestake Mining Co., as described by R. G. Wayland,[1] the assistant

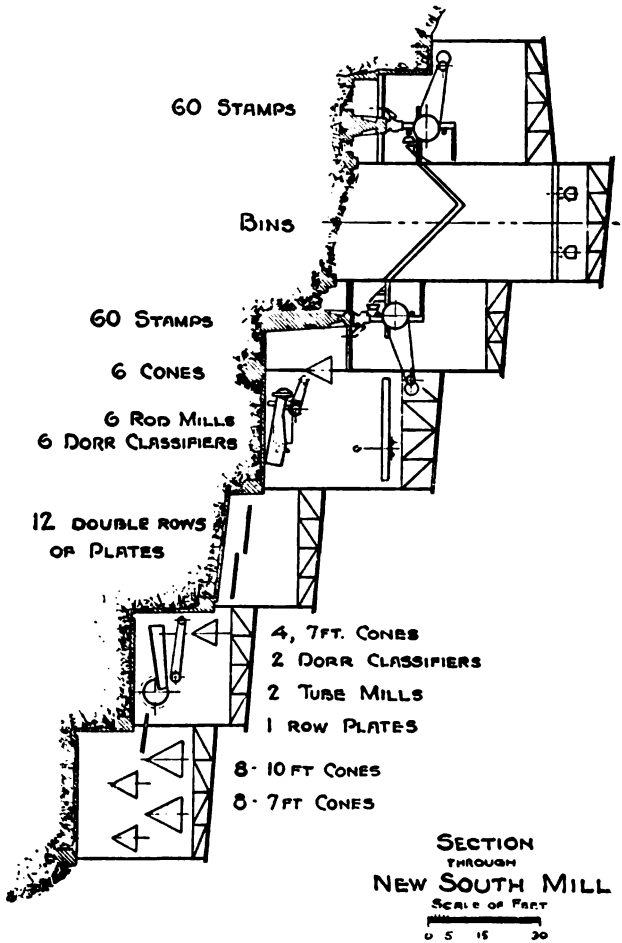

FIG. 8.

superintendent. This plant is 2000 ft. east of the Ellison shaft, from which it receives a 2-in. product, and on one side of a ridge immediately south of and above No. 1 cyanide plant, which treats sand from the stamp-mills at Lead. The reason for constructing this mill is because the site of the Homestake 220-stamp mill has been undermined. The flow-sheet

[1] *Pahasapa Quarterly*, South Dakota School of Mines, Feb., 1921.

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is self-explanatory. The steel ore-bin is of 6000 tons capacity. The two rows of sixty 1550-lb. stamps each are set back-to-back. They will crush through ½-in. screens. Re-grinding is done in rod-mills and tube-mills in close-circuit with classifiers. There are two lots of copper plates for amalgamation. The final pulp flows to No. 1 cyanide plant for complete separation into sand and slime. The daily capacity of the new mill is rated at 1800 tons. The flow-sheet was determined by Allan J. Clark, metallurgist for the company.

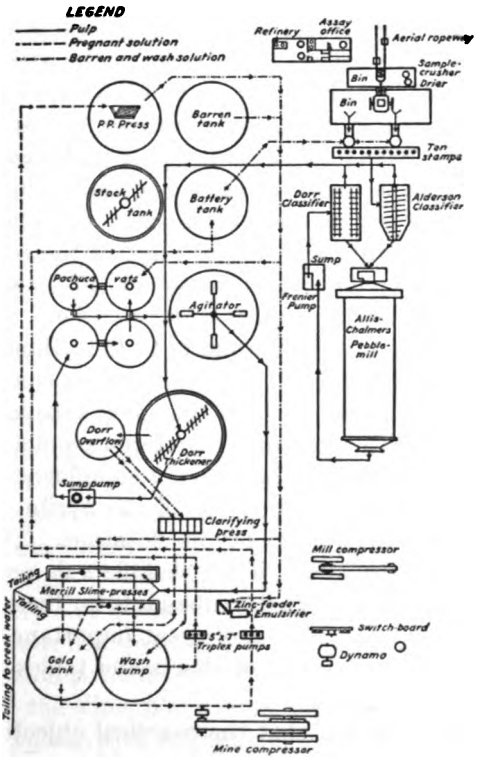

FIG. 9.—Flow-sheet of Nugget mill.

The accompanying flow-sheet (Fig. 9) is that of the mill at the Nugget gold mine in the Nelson district of British Columbia, according to G. H. Shepherd.[1] The ore is oxidized to a depth of 1050 ft., but contains some pyrite, galena, chalcopyrite, and sphalerite; also malachite and native copper, which sometimes cause trouble. An aerial tram 3800 ft. long connects the mill with the mine, which is at an elevation of 5325 ft. Coarse ore is broken by a jaw-crusher, and lime is added to the ore at the

[1] *Min. Sci. Press*, **124**, 51 (1922).

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upper bin. The stamps crush the ore in cyanide solution at the rate of 6 tons per day each through ¼-in. screens. After classification, fine grinding, and agitation, the slime is washed in Merrill presses, and the gold in the pregnant solution is precipitated by "merrillite," a zinc-dust mixture. The extraction is 97 per cent., and consumption of cyanide (Aero) is 1.55 lb. per ton of ore, 2.45 lb. of lime, 0.55 lb. of merrillite, and 0.002 lb. of lead acetate (used as a drip before precipitation). The precipitate is treated with sulphuric acid, air-dried, mixed with borax glass, sodium carbonate, silica, fluorspar, and niter, and then melted in a No. 100 crucible in a gasoline furnace. The plant is driven by 8 Pelton wheels, under a head of 650 ft., but owing to climatic conditions, mill-runs seldom cover more than five or six months out of twelve.

The remodeled mill of the Alaska Juneau Co. at Juneau, Alaska, is now able to treat 7000 tons of $1 ore daily and recover about 72 per cent. at a milling cost of under 40 cents per ton. This cost is expected to be reduced to 28 cts. or under later on. The main feature of the new process is the discarding of 45 per cent. of the rock as waste, and concentrating the remainder. The output in 1921 was 4482 tons daily of ore averaging 85.41 cts. per ton, of which 61.77 cts. was recovered.

In his paper[1] entitled "Distribution of Gold in Banket Ore Classified Products, with Reference to Milling and Cyaniding Operations," F. Wartenweiler said that the constituents of the ore are banket and associated quartzite, shale, and dike rock; and that from a practical metallurgical standpoint the investigation points to the significant fact of the need for fine comminution (minus 200 mesh) of the pyrite. This conclusion is based on a long series of tests by ore flotation. The importance of careful classification follows, and if the classifiers do not return the plus 200-mesh pyrite and free gold to the tube-mills for further grinding, then the plant is handicapped. This is of great importance in treating ores of the Far East Rand. A series of charts and tables accompanied this paper.

W. A. Caldecott[2] thought that the practical objective would be efficient and prompt amalgamation of all free gold possible in the tube-mill outflow-pulp. Coarseness of gold particles facilitates amalgamation, and recovery by this means reduces the value of the final tailing pulp, thereby facilitating cyanide treatment and producing low residue therefrom, with consequent high total gold recovery.

H. A. White[3] supported Mr. Caldecott, while A. King[4] thought that Mr. Wartenweiler had further emphasized the need for fine grinding of Rand ore.

[1] *Jour. Chem. Met. Min. Soc. So. Afr.*, **21**, 217 (1921).
[2] *Op. cit.*, **22**, 24 (1921).
[3] *Op. cit.*, **22**, 35 (1921).
[4] *Op. cit.*, **22**, 36 (1921).

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The antimonial-gold ore from the Globe and Phoenix mine in Southern Rhodesia averages about 0.73 per cent. Sb, 0.96 S, a trace of As, 1.21 CaO, 6.44 Mg, 25.8 Fe and 76.32 per cent. SiO_2. The amount of antimony varies, and samples over a period of three weeks averaged 2.39 per cent.; also 0.26 per cent. arsenic. Much of the gold is free and easily amalgamated on plates; some of it is coated, but is amalgamated in grinding pans; while some escapes from the pans and is retained on canvas strakes. The total gold amalgamated is 65 to 70 per cent. On account of the stibnite, and possibly ferrous iron, the tailing cannot be cyanided direct; but if allowed to oxidize partly by weathering, it becomes amenable to cyanide.

The flow-sheet includes breaking the ore in jaw-crushers; screening, washing, and sorting out the stibnite; crushing with forty 1250-lb. stamps through 200-mesh screen; amalgamating on plates and in grinding pans; pulp passes over canvas strakes 19 by 53 ft. in area, and is then separated into sand and slime, which go to a separate dump and dam. When first discharged, these two products have a dull bluish-gray appearance, which changes to yellowish as oxidation proceeds, according to V. E. Robinson.[1]

Of the sand returned to the 300-ton leaching plant, after being on the dump for 6 months, 5 per cent. is plus 30 mesh, while 24, 25, 18, and 28 per cent., respectively, are minus 30, 60, 90, and 150 mesh. The cyanide strength is 0.03 per cent. KCN, and consumption is 1.1 lb. per ton, with 0.2 lb. of lead nitrate. Extraction is from 75 to 80 per cent. on 6-dwt. ($6) weathered sand, with 7 days treatment, but only 61 per cent. on current sand with 5 days, while cyanide consumption on the latter is nearly double. The partly dried slime dams are plowed to a depth of 14 in. every 5 or 6 weeks. After oxidizing for 20 days, the slime is mixed with cyanide solution and treated by agitation and decantation. Cyanide consumption is 1.6 lb. per ton, and the extraction is 80 per cent. Gold bullion from the slime plant often contains considerable copper, so it is granulated, mixed with sulphur, and treated slowly in a graphite pot. The copper and other base metals, and some of the antimony and silver enter the matte, while the bullion is re-melted in a clay-lined crucible. The matte is crushed fine, mixed with an equal weight of borax, and a quarter of its weight of crushed cyanide, and melted until action ceases. Practically all of the silver and gold therein is recovered as fairly fine bullion, and after refining is mixed with the bullion from sulphur treatment.

The paper was discussed by G. W. Dimond,[2] who thought that not enough details were given, and then gave his own experiences on similar

[1] *Jour. Chem. Met. Min. Soc. So. Afr.*, **21**, 117 (1921). [2] *Op. cit.*, 169.

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ore at the Jessie mine, in the Bulawayo district. If the tailing was not oxidized sufficiently, that is, to a yellow color, the extraction would be poor, with or without alkaline treatment; but by crushing in a strongly alkaline solution—0.1 per cent. KCN + 0.02 per cent. CaO—and direct filling in leaching vats, and preventing oxidation by exposure to air, a

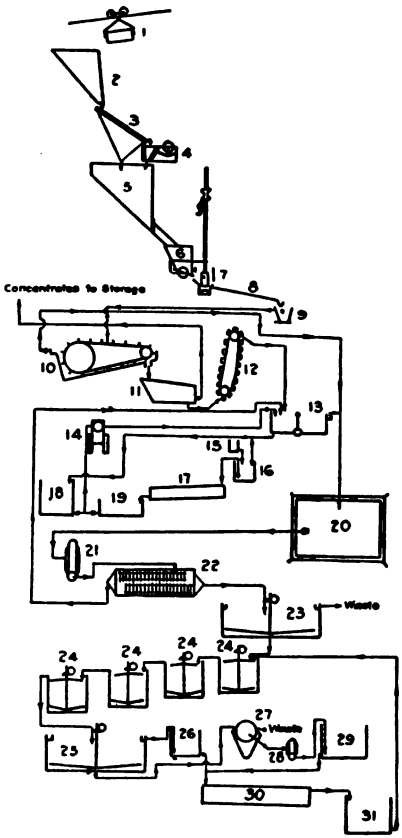

FIG. 10.—Flow-sheet of Gold Bullion mill and cyanide plant, Alaska.

1. Jig-back tramway. 2. Receiving-hopper. 3. Grizzlies. 4. Blake crusher. 5. Storage-bin. 6. Challenge feeders. 7. Stamp-batteries. 8. Amalgamating plates. 9. Amalgam-traps. 10. Esperanza drag-classifier. 11. Wilfley concentrating table. 12. Bucket-elevator. 13. Leaching-vats. 14. Solution-pump. 15. Sweetener barrel. 16. Distributing barrel. 17. Zinc-boxes. 18. Solution-tank. 19. Sump-tank. 20. Slime-pond. 21. Krogh centrifugal pump. 22. Dorr duplex classifier. 23. Dorr thickener. 24. Agitators. 25. Dorr thickener. 26. Clarifying tank. 27. Oliver filter. 28. Centrifugal pump. 29. Storage-tank. 30. Zinc-boxes. 31. Sump-tank.

7-dwt. ($7) tailing gave 90 per cent. extraction. It was also found that 40 per cent. of the mill-pulp leached well enough to remove the soluble gold, so no slime plant was erected. This process is now giving good results.

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The Gold Bullion mill and cyanide plant in the Willow Creek district of Alaska, 25 miles from the new Government railroad, is in a very promising region for the development of quartz mines, according to O. A. Glaeser.[1] The mine is at an elevation of 4500 ft., and the mill is 1450 ft. below it, connected by jig-back tram. The ore is quartz in granodiorite, and is treated according to the accompanying flow-sheet (Fig. 10). Concentrates assay $127 per ton. Owing to climatic conditions, the cyanide plant ceases operations for the winter several weeks before the mill does, and the sand is stored for treatment next summer. Fresh sand receives about 2⅓ lb. of lime and old sand 1¾ lb. per ton, in the form of milk of lime. Extraction is 71 per cent. The slime is agitated and filtered, this simple treatment giving good results. The cost of leaching sand is $2.015 per ton and $8.709 per ounce of gold.

A dump of 40,000 tons of slime tailing at the Coniagas mine at Cobalt, Ontario, contained 6 oz. of silver per ton, and was successfully treated by cyanidation, according to H. E. Cawley.[2] The greatest difficulty encountered was in collecting and conveying the slime to the works; however, this was accomplished with a Sauerman dragline scraper which handles 100 tons of dry material per day of 24 hr. The screened slime is washed into a collecting tank fitted with a mechanical agitator by barren cyanide solution. About half of the silver is in solution before the pulp is pumped to the treatment plant, 1350 ft. distant. Before pumping, the solution is made up to 0.25-per cent. strength. The subsequent process is agitation in Pachuca tanks for 24 hr., and filtration. The pregnant solution, assaying 5 or 6 oz. per ton, is precipitated by adding 0.05 lb. of sodium sulphide per ounce of silver contained. The precipitate is collected in a Perrin press. Consumption of cyanide is 3 lb. per ton treated. Extraction is 83 per cent., and cost about 35 cts. an ounce.

Construction and operation of a 280-ton mill and cyanide plant in Ecuador was described in detail by Paul C. Schraps.[3] The Zaruma mines, where the plant was erected, is 15 miles by launch or river steamer from the Pacific port of Puerto Bolivar, then 46 miles by mule trail over a divide at an elevation of 6500 ft., then down to the property at 2000 ft. Transportation is therefore difficult and costly. The ore is mostly quartz and calcite with 1 parts gold to 3.75 parts silver by weight. Prior to early 1919 the mode of treatment was amalgamation and cyanidation of the sand, which recovered about 75 per cent. during 1917 and 1918. The leached sand and the slime were stored. Amalgamation has since been abandoned. It was decided to erect an all-sliming plant with the Dorr counter-current decantation system. As the local lumber was

[1] *Min. Sci. Press*, 122, 601 (1921).
[2] *Eng. Min. Jour.*, 112, 890 (1921).
[3] *Eng. Min. Jour.*, 111, 579 (1921).

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unsuitable for the thickeners and agitators, they were built of reinforced concrete. This work required considerable care to make the concrete impervious. The total cost was 427,173 sucres ($213,500), 70 per cent. for supplies and 30 per cent. for labor. Stamping is done in cyanide solution, and the screens are 4-mesh. River pebbles are used in the tube-mills, but the consumption is 110 lb. per ton of ore. Mine ore is unsatisfactory for this purpose. The Crowe vacuum system of precipitation reduced consumption of merrillite by nearly 50 per cent. Total costs of treatment were 3.57 sucres ($1.78) per ton in 1920.

During 1921 the Hollinger mill treated 1,072,493 tons of ore averaging $9.67 gold per ton, and extracted 97 per cent. at a cost of $1.46 per ton. The plant was described in a paper[1] prepared by the Staff and presented at the annual meeting of the Canadian Institute of Mining and Metallurgy. Coarse crushing is done by Gates breakers and rolls. Between the breakers and rolls are revolving trommels, also a magnet pulley to catch pieces of tramp steel. Fine crushing and grinding is done by one 7 by 6-ft. ball-mill and 200 stamps of 1500 and 1625 lb. weight, all fitted with ⅜-in. screens, and 22 tube-mills which make a product of which 70 per cent. passes 200 mesh. This department is composed of one ball-mill unit, and 20 units each of 10 stamps, one tube-mill, and one classifier. The pulp is thickened, agitated with cyanide in mechanical agitators, and filtered on leaf-filters; also part is treated by counter-current decantation. Zinc dust, with the vacuum system, is employed for precipitation. A clean-up is made once a week. The precipitate is fluxed with borax, litharge, pyrite cinders, and quartz, and melted in a lead blast-furnace, after which the lead bullion is cupelled, yielding bullion 810 fine in gold and 140 fine in silver. Consumption of cyanide is 0.52 lb. per ton of ore, 0.38 lb. mechanical loss and 0.14 lb. chemical loss. Lime consumption is 2.45 lb. per ton.

[1] *Bull. Can. Inst. Min. Met.*, March, 1922, p. 326.

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GRAPHITE

By Benjamin L. Miller

During 1921 the graphite industry of the world was practically dead. No other year since the development of the industry has been equally disastrous to the graphite producers of all countries, and at the close of the year no relief was in sight, although everywhere it was confidently expected that conditions would improve as business generally recovered from the prevailing industrial depression.

The situation can be definitely attributed to a few causes well recognized by everyone familiar with the industry. The principal one is the increased stimulation during the war and the consequent collapse at its close. The demand for crucible steel for war purposes created an unusual demand for graphite crucibles and scores, perhaps hundreds, of new graphite mines were developed in Ceylon, Madagascar, the United States, Canada and other less important graphite-producing countries. The sudden ending of the war found the crucible-steel manufacturers with large supplies of crucibles on hand, the crucible manufacturers with an excessive amount of graphite in stock which they had acquired on account of the uncertainty of supply, due largely to the transportation difficulties, and the graphite producers in turn with supplies of refined and crude graphite on hand sufficient to meet even the inflated needs of war times for many months or even years. In the present state of business there has not been sufficient time to exhaust the surplus, and until that is accomplished stagnation of the entire industry is the inevitable result. The amount of surplus material on hand is not known, but it is believed that it is still large enough to prevent resumption in the near future.

Prices

The prices of all kinds of graphite were low during the year and yet they showed considerable variation. Most of the sales involved the disposal of material produced at the peak of war-time prices and were sold at heavy losses. Forced sales resulted in prices far below present production costs in even the most favored countries. Ceylon lump f.o.b. New York sold at 4½ to 6 cts. a lb., chip 3½ to 5 cts., and dust 1½ to 3¾ cts. Madagascar graphite flake of good quality sold in New York for 3½ to 4 cts. per lb. and occasional lots at even lower prices. The average selling price of domestic flake at the mines was 6.4 cts. It

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is doubtful whether Ceylon or the United States can produce with profit at these prices and it is not even certain that Madagascar can continue.

The average selling price of amorphous graphite was $11.32 per ton.

Graphite Production in the United States

There were only eight domestic graphite firms that reported production in 1921. They were in order of production as follows:

Crystalline or flake graphite.
- New York: Joseph Dixon Crucible Co.
- Texas: Southwestern Graphite Co.
- California: California Graphite Co.
- Alabama: Flaketown Graphite Co. and Superior Flake Graphite Co.

Amorphous graphite.
- Rhode Island: Graphite Mines Corporation.
- Nevada: Carson Black Lead Co.
- Colorado: Graphite Corporation.

In comparison with 1920 the tables show a three-fourths reduction of combined crystalline and amorphous graphite. Alabama for the first time in many years drops into fourth place, with New York resuming the lead. Pennsylvania and Montana reported no production. This is also unusual, as Pennsylvania long held second or third place in the production tables and Montana has had one mine in operation every summer for years past. The production of manufactured graphite, produced by the Acheson Graphite Co. of Niagara Falls, N. Y., also decreased.

STATISTICS OF PRODUCTION IN THE UNITED STATES

Year.	Refined Crystalline Graphite.						Amorphous Graphite Production.	
	Production.		Imports. (c)		Consumption. (a)			
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Short Tons.	Value.
1905	4,260,656	$170,426	34,914,611	$ 983,034	39,175,267	$1,153,460	21,953	$80,639
1906	4,894,483	170,866	50,974,336	1,554,212	55,868,819	1,725,098	16,853	(b)
1907	4,586,149	149,548	40,962,000	1,777,389	45,548,149	1,926,937	26,962	138,381
1908	3,433,039	149,763	22,912,714	762,267	26,345,753	876,030	1,433	75,250
1909	5,669,899	340,194	42,532,851	1,854,459	48,202,750	2,194,653	5,096	32,238
1910	5,625,132	286,882	50,610,560	1,872,592	56,235,692	2,159,474	1,407	39,710
1911	4,790,000	256,050	41,404,000	1,495,729	46,194,000	1,751,779	1,223	32,415
1912	3,543,771	187,689	51,286,000	1,709,337	50,188,969	1,553,568	2,063	32,894
1913	5,064,727	254,328	57,758,400	2,109,791	57,439,146	1,972,213	2,243	39,482
1914	5,220,539	285,368	44,004,800	1,398,261	45,304,646	1,406,243	1,725	38,750
1915	7,074,370	417,273	46,155,200	2,241,163	52,163,866	2,605,420	1,181	12,358
1916	10,931,989	914,748	86,033,920	7,279,884	95,370,301	8,096,514	2,622	20,723
1917	10,584,080	1,094,398	85,218,000	8,961,988	90,655,264	9,706,823	8,301	73,481
1918	12,861,839	1,454,799	38,996,160	3,092,475	49,950,280	4,425,719	6,560	69,455
1919	8,036,191	731,141	53,251,520	2,978,096	60,079,671	3,619,052	3,379	47,716
1920	9,632,360	576,443	42,190,400	1,711,312	50,609,144	2,174,984	4,694	49,758
1921	1,190,000	75,664	16,791,040	452,076	16,139,462	431,742	1,842	20,860

(a) Production (sales) plus imports minus exports. (b) Not reported. (c) Includes amorphous.

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PRODUCTION OF MANUFACTURED GRAPHITE

Year.	Quantity, Pounds. Made in Canada.	Made in U. S.	Value.	Price per Pound, Cents.
1899	.....	405,870	$32,475	8.00
1900	.....	860,750	68,860	8.00
1901	.....	2,500,000	119,000	4.76
1902	.....	2,358,828	110,700	4.69
1903	.....	2,620,000	178,670	6.82
1904	.....	3,248,000	217,000	6.70
1905	.....	4,595,500	313,979	6.83
1906	.....	4,868,000	312,764	6.42
1907	.....	6,924,000	483,717	6.97
1908	.....	7,835,511	520,667	6.80
1909	.....	6,870,529	467,196	6.80
1910	.....	13,149,000	945,000	7.19
1911	.....	10,144,000	664,000	6.54
1912	.....	12,896,347	830,193	6.44
1913	.....	13,633,342	973,397	7.14
1914	.....	10,455,139	698,800	6.68
1915	(a) 497,271	(a) 5,083,166	109,102	1.96
1916	(a) 525,048	(a) 8,397,281	.....	....
1917	(a)1,096,172	(a)10,474,649	.....	....
1918	(a)1,808,698	(a) 9,182,272	.....	....
1919	(a) 358,524	(a) 8,163,177	.....	....
1920	(a) 207,180	(a) 7,399,749	.....	....
1921	.....	(a) 5,888,000	.....	....

(a) Powdered graphite only; electrode material not included.

Conditions in the United States.—The graphite producers of the country continued during the year to urge Congress to impose a tariff on graphite sufficient to prevent the importation of foreign materials at prices lower than the cost of production in this country. The matter was still under discussion at the close of the year. Unless a tariff is imposed it is questionable whether the domestic flake graphite producers can successfully compete with the Ceylon producers, whose product is considered superior for crucible manufacture, or with the graphite producers of Madagascar, whose product is similar to the domestic flake and who can put it upon the market at lower costs than have ever been realized in this country. The reduction in water-transportation rates has still further aggravated the situation. Graphite of the flake variety, unlike some of our other mineral products, exists in such quantities in Alabama, New York, Pennsylvania, Texas, and other states that there is no reason why it should be conserved for war or other emergencies, yet Congress has been loath to impose a protective tariff that would increase the cost of the manufactured products to the consumer with the insistent demands from the public for lower prices. However, it seems probable that a reasonable import tariff will probably be placed on graphite. This will not save many of the companies that used poor judgment in the location and equipment of their plants and even the best of the concerns must perfect their concentrating and refining methods to compete with foreign producers. It is certain that much of the money invested in graphite operations during the war can never be recovered.

The experimental work of the Bureau of Mines gives encouragement to the domestic flake graphite producers, as described in the following quotation:

Early in 1918 the Columbus station of the U. S. Bureau of Mines

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began an investigation of American bond clays and graphites to determine their crucible-making properties in comparison with foreign clays and graphite. Work on the bond clays, which was completed in the fiscal year 1920, showed that better crucibles could be made from domestic clay than from imported clays. The testing of graphites, on which some preliminary work had been done, was then undertaken by the Bureau of Mines. Samples of seven graphites, from Ceylon, Madagascar, Canada, New York, Alaska, Texas, and Montana, of 400 lb. each, were obtained. Then crucibles of No. 70 size were made from each graphite for brass-melting purposes, and six crucibles of No. 60 size for testing under steel-melting practice. These crucibles were made in the plant of the Vesuvius Crucible Co., at Swissvale, Pa. The brass-melting crucibles were shipped to the plant of the Detroit Lubricator Co., at Detroit, Mich., where they were tested under regular brass-melting practice.

Arrangements were made for testing the steel-melting crucibles in the plant of the Simonds Manufacturing Co., at Lockport, N. Y., but when the crucibles were ready for shipment word was received that the pit furnaces of the Simonds steel plant were not in operation, and as they have not been in operation since that time, it has been impossible to test the steel-melting crucibles.

In the brass-melting tests, the average number of heats of the crucibles shown by the different graphites are as follows: Alabama, 13.09; Madagascar, 12.44; Ceylon, 10.50; New York, 9.60; Texas, 6.80; Montana, 6.11; Canadian, 5.80. These results indicate that good brass-melting crucibles can be made from Alabama graphite, and agree with the findings of previous work.

Imports.—The U. S. Geological Survey publishes the following table showing the imports of graphite during recent years as reported by the Bureau of Foreign and Domestic Commerce. All of the material coming from Ceylon, Madagascar, and Canada was crystalline graphite. Most, if not all, obtained from the other countries was amorphous.

GRAPHITE IMPORTED INTO THE UNITED STATES
(In short tons)

Country of Origin.	1915.	1916.	1917.	1918.	1919.	1920.	1921.
Ceylon	14,491	26,232	24,575	9,029	9,451	9,204	2,311
Madagascar	1,468	1,631	4,393	970	10,016	4,710	1,078
Canada	2,995	4,127	3,476	3,084	1,504	2,170	687
Brazil	.....	1	18	45	.....	.....	.....
Mexico	1,680	5,331	7,570	5,600	5,506	3,659	3,404
Chosen (Korea)	2,373	5,375	2,462	568	126	810	646
Italy	27	151	115	17	22	137	48
Austria	.....	.....	.....	.....	.....	58	.....
Germany	.....	.....	.....	.....	.....	30	.....
Other countries	41	169	.....	185	1	317	10
	23,075	43,017	42,609	19,498	26,626	21,095	8,183

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Graphite in Foreign Countries

Canada.—The Dominion Bureau of Statistics furnishes the following information concerning the graphite industry of Canada.

The production of graphite in Canada during 1921 was practically negligible, the entire mine output being only 1500 short tons, all of which was produced from the Black Donald mine at Calabogie, Ontario. The total shipments from all graphite properties in Canada during 1921 amounted to 398 tons and were valued at $25,606. By grades these shipments consisted of 6 tons of No. 1 flake, valued at $2059; 17 tons of No. 2 flake, valued at $3398; 375 tons of No. 3 flake and dust, valued at $20,239.

The Black Donald was the only shipper in Ontario and the Quebec Graphite Co. was the only company in that Province to ship graphite during the year. None was mined by the latter company, shipments being made from stock. At the close of the year stocks aggregating 700 tons remained unsold at the mines.

Imports of graphite and its products during 1921 showed a considerable decline, as might be expected from the records for the preceding years. A total of $75,390 worth of graphite products was imported. Exports during the same period were valued at $40,809, and the quantities reported by the Department of Customs totaled 614 tons. While this amount is considerably in excess of the tonnage shown as shipped from the mines, it is probable that considerable quantities were moved to Canadian warehouses in the United States early in the year in anticipation of adverse tariff legislation being put into effect in that country.

GRAPHITE STATISTICS IN CANADA

	1920.		1921.	
	Short Tons.	Value.	Short Tons.	Value.
Ore mined	.....	.....	1,500	.....
Refined graphite sold:				
No. 1 flake	196	$40,382	6	$2,059
No. 2 flake	225	28,572	17	3,398
No. 3 flake and dust	1,769	96,663	375	20,239
Total	1,190	165,617	398	25,696
Imports	.....	283,631	.....	75,390
Exports	2,142	159,817	614	40,809

Ceylon.—Graphite mining in Ceylon during the year was practically at a standstill and the stocks on hand were not materially reduced. Less graphite is said to have been shipped from the island than during any previous year for twenty years past. Graphite could be purchased

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for less than the cost of production due to the inability of some firms to hold their stock for higher prices. The supplies in Ceylon, Europe, and the United States seem to be ample for several years unless there should be an unexpected sudden demand for graphite crucibles. Under these conditions there is no prospect of immediate improvement.

Madagascar.—Almost the same description as given for Ceylon might be used for Madagascar. The flake-graphite stocks from this island are large and are held in Madagascar, France, England, and America. Forced sales were made during the year at figures far below the cost of production. The stock will be held for higher prices even though it is believed that it might be several years before it is needed.

Other Countries.—The minor graphite-producing countries were affected in the same manner as Ceylon and Madagascar. Reports indicate that there was some desultory mining in several of them and small shipments were made, but there were no new developments of importance.

WORLD'S PRODUCTION OF GRAPHITE
(In metric tons)

Year.	Austria.	Bavaria.	Canada. (c)	Ceylon. (a)	India.	Italy.	Japan.	Mexico. (b)	Sweden.	United States. (c)	France and Colonies.
1905	34,416	3,784	491	31,134	2,361	10,572	209	970	40	1,933	.....
1906	38,117	4,921	405	36,578	2,642	10,805	177	2,915	37	2,220	.....
1907	49,425	4,055	525	33,027	2,472	10,989	103	3,202	33	2,080	.....
1908	44,425	4,033	227	26,227	2,919	12,914	177	1,076	66	1,557	309
1909	40,710	4,844	783	25,995	3,182	11,583	284	1,704	26	5,875	320
1910	33,131	(e)4,900	1,263	30,008	4,319	12,510	145	2,571	49	3,811	1,100
1911	41,599	7,415	1,154	27,433	4,047	12,621	114	3,050	65	3,280	1,870
1912	45,375	11,298	1,873	33,106	*Nil.*	13,170	149	3,518	79	3,318	5,600
1913	49,456	12,532	1,961	29,277	*Nil.*	11,145	665	4,435	88	4,331	(d)7,220
1914	.....	12,032	1,494	14,451	*Nil.*	8,567	574	4,259	56	3,935	(d)7,747
1915	.....	13,600	2,368	22,159	71	6,176	666	4,189	87	4,280	(d)11,850
1916	.....	16,900	3,589	33,947	1,841	8,182	1,144	470	194	7,339	(d)25,480
1917	.....	30,600	3,369	27,482	105	12,117	1,329	420	128	12,231	(d)35,000
1918	.....	37,500	2,768	15,702	82	11,653	.....	6,190	.....	11,785	(d)16,000
1919	.....	.....	1,234	6,778	129	7,626	.....	4,023	.....	6,733	(d)5,000
1920	.....	.....	2,020	.....	102	5,398	.....	3,223	7	8,627	(d)4,500
1921	.....	.....	361	.....	.....	5,750	.....	2,911	.....	2,211	.....

(a) The figures for 1907, 1908, and 1912 to 1919 are exports. (b) Exports until 1910. (c) Crystalline graphite up to 1909. Does not include artificial graphite. (d) Madagascar. (e) Estimated.

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GYPSUM

By Frank A. Wilder

Less gypsum was mined in the United States in 1921 than in the preceding year, though the tonnage was greater than for any previous year excepting 1920. The United States Geological Survey has estimated that the output for 1921 was approximately 3,050,984 short tons. This figure may be compared with 3,129,142 tons mined in 1920, and 2,756,630 tons mined in 1916, which year previous to 1920 held the record for gypsum production. The combined value of crude and calcined gypsum sold was approximately $23,700,290 as compared with $24,533,065 in 1920.

These figures indicate that the gypsum industry fared better than most enterprises during the year 1921. The country has not recovered from the war period when building of the kind that uses gypsum products was discouraged, and the construction of homes, schools, churches, and apartment houses was brisk during a year when industrial construction was quiet. The price of crude gypsum for use in Portland cement declined a dollar in most districts, and by the end of the year the price of calcined gypsum and of gypsum plaster had declined two dollars a ton.

CRUDE GYPSUM MINED IN THE UNITED STATES (a)
(Tons of 2000 lb.)

1887	95,000	1899	486,285	1911	2,323,970
1888	110,000	1900	594,462	1912	2,500,757
1889	267,769	1901	633,791	1913	2,599,506
1890	182,995	1902	816,478	1914	2,476,465
1891	208,126	1903	1,041,704	1915	2,447,611
1892	256,259	1904	940,917	1916	2,756,630
1893	253,615	1905	1,043,202	1917	2,696,226
1894	239,312	1906	1,540,585	1918	2,057,015
1895	265,503	1907	1,751,748	1919	2,420,163
1896	224,254	1908	1,721,829	1920	3,129,142
1897	288,982	1909	2,252,785	1921	3,050,984
1898	291,638	1910	2,379,057		

(a) Statistics of the U. S. Geol. Surv.

TOTAL VALUE OF CRUDE AND CALCINED GYPSUM

1908	$4,075,824	1913	$6,774,822	1918	$11,470,854
1909	5,906,738	1914	6,895,989	1919	15,727,907
1910	6,523,029	1915	6,596,893	1920	24,533,065
1911	6,462,035	1916	7,959,032	1921	23,700,290
1912	6,563,908	1917	11,116,452		

The output of gypsum wall-board increased during the year, and exports of this commodity were considerable. The manufacture of gypsum wall-board is a new and promising phase of the industry and the

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tonnage produced may be expected to show a healthy increase for some years to come.

Steady progress was made in advancing the interests of agricultural gypsum. Abundant and substantial scientific data are now available and a correct understanding of the value of gypsum in agriculture is being fostered by the educational campaign of the Gypsum Industries Association. This is reflected by the amount of space devoted to agricultural gypsum in farm papers and in experiment-station bulletins. A few of the more important of these papers are listed in the bibliography at the end of this article.

Progress in standardizing gypsum products was made during the year, due to the efforts of the Bureau of Standards and Committee C–11 of the American Society for Testing Materials.

From a technical point of view the chief feature of the year was the development of a process for making calcined gypsum more plastic. The process was the result of the work of W. E. Emley, of the Bureau of Standards, who has given the results of his work without reservation to citizens of the United States, while reserving patent rights outside of this country. Plasticity is a property highly important for calcined gypsum and gypsum plasters, and the new process promises to become of considerable importance, and may permit the use of calcined gypsum for certain purposes for which, heretofore, it was not well adapted.

CRUDE GYPSUM MINED IN THE UNITED STATES (a)

State.	1917. Quantity Mined (Short Tons).	1918. Quantity Mined (Short Tons).	1919 Quantity Mined (Short Tons).	1920. Quantity Mined (Short Tons).	1621. Quantity Mined (Short Tons).
Iowa	461,864	327,927	421,279	571,895	350,247
Kansas	79,331	54,958	78,479	130,044	92,526
Michigan	375,803	286,768	339,125	382,212	408,224
New York	606,268	531,038	591,153	780,295	712,665
Ohio	270,538	199,456	251,259	277,899	363,905
Oklahoma	158,017	126,208	114,313	135,279	209,201
Texas	257,328	157,388	176,607	220,157	232,806
Wyoming	55,844	41,877	51,079	57,732	38,927
Nevada	(c)	(c)	91,756	143,929	178,275
Other States	(b)431,223	331,395	305,113	429,700	464,208
	2,696,226	2,057,015	2,420,163	3,129,142	3,050,984

(a) R. W. Stone, U. S. Geol. Surv. (b) Includes Arizona, California, Colorado, Montana, New Mexico, Oregon, South Dakota, Utah, Virginia. (c) Included with "Other States."

The following news notes indicate that more than the usual amount of construction work was undertaken in 1921.

Arizona.—The Arizona Gypsum Co., Phoenix, is reported to have leased its properties to the Arizona Gypsum Products Co. of Los Angeles. This company plans to erect a mill and have it in operation by 1922.

California.—The Imperial Gypsum and Oil Co., San Diego, has begun

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construction of 18 miles of railroad from Maria on the San Diego & Arizona R. R. to its gypsum deposits 28 miles west of Westmoreland. Plans have been drawn for a large mill.

The Gypsum Fertilizer Co., Los Angeles, has been organized to manufacture agricultural gypsum. The plant will be located 14 miles northwest of Saugus.

The California Gypsum Co., Los Angeles, has plans under way for the erection of a plant in Imperial County near Covoto Wells, 22 miles northeast of El Centro.

Iowa.—The Iowana Gypsum Products Co. completed a large mill and has it in full operation.

New York (By D. H. Newland).—The gypsum mines and mills of the State had a fairly active year in 1921, contrary to the general experience of other mineral industries, for most of which it was a period of great depression and even disaster. The gypsum plants were sustained by a revival of the building trades that began rather late and did not reach its anticipated proportions, but still sufficed to keep a healthy market for calcined products, which are the main support of the local industry. Only one or two of the mines depended principally or solely upon the sales of crude rock, and for them the conditions were not so favorable. The requirements of gypsum for cement manufacture were considerably smaller than in the preceding year.

Interest in the gypsum fields of western New York continues unabated apparently. Exploration was in progress in Genessee and Erie counties, which contain the main resources of high-grade rock, but the results of the work have not yet been made known. Some of this was for the purpose of increasing the mine reserves in opened territory, and the outcome may be forecasted with some degree of certainty; elsewhere the results are more problematical. The Phoenix Gypsum Co. began active mining during the year on its properties at Wheatville Station, west of Oakfield. The mine is opened by a vertical shaft, with two hoisting compartments, about 60 ft. deep. The workings are mostly to the west of the shaft and so far they show a bed of high-grade gypsum about 4 ft. thick. The output is all shipped in crude form, except for crushing, which is effected by a single pass through a hammer machine. It goes mostly to the cement mills of eastern New York and Pennsylvania. The Oakfield Gypsum Products Corporation has opened properties to the east of the Phoenix company's and has completed plans for a mill for wall-plaster manufacture. The American Hard Wall Plaster Co. of Utica and the Paragon Plaster Co. of Syracuse are interested in the enterprise, and will give an immediate outlet for a considerable part of the output. Work on the new plant was started early in 1922. The

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Ralph Gypsum Co., which leased a large area in the eastern part of Genesee County, near South Byron, confined its activities to testing of the ground. The International Gypsum Co., with properties north of Le Roy near the Genessee-Monroe County line, also made no production. The American Gypsum Co., of Akron, one of the original enterprises in that district, has heretofore shipped crude gypsum only, but has started work on a calcining plant which will manufacture most of the output in the future.

With the rapid growth of the industry in western New York may be noted the decline almost to extinction of the earlier established operations in the central part of the State, in Madison, Onondaga and Cayuga counties, where important deposits occur but of lower grade than the rock in the western section. This material is now used only for agricultural plaster to supply purely local demands.

PRODUCTION OF GYPSUM IN NEW YORK (a)

Material.	1919.		1920.		1921.	
	Short Tons.	Value.	Short Tons.	Value.	Short Tons.	Value.
Output, crude	591,153	.....	780,295	.....	712,665	.....
Sold, uncalcined	216,417	$620,339	271,077	$987,503	206,304	$694,518
Sold, manufactured forms	316,767	2,910,404	387,856	5,451,426	401,441	5,457,310

(a) U. S. Geol. Surv. and N. Y. State Geol. Surv.

New York is a larger factor in the wall-plaster trade than appears in the production tables, for a very considerable tonnage of imported rock is calcined and manufactured by plants located on tidewater. The rock comes from Nova Scotia and New Brunswick. Favored by a low duty and reasonable freights it can compete successfully with domestic gypsum, which reaches its markets by rail at proportionately higher costs. The importations, which were greatly reduced during the later years of war, have been resumed on nearly the former scale, some 300,000 tons as an average.

Texas.—The American Cement Plaster Co. made some improvements in its mill at Agatite, which uses gypsite from local beds. Rock gypsum of good quality exists on their property, but has not been developed. The Acme Cement Plaster Co. at Acme, in the same district, produces both rock and earth, the first being partly shipped crude to cement plants and partly calcined for manufacture of Keene's cement, blocks and tile. The Texas Cement Plaster Co. opened a gypsite mill near Hamlin. It is reported that the U. S. Gypsum Co. contemplates extensive developments near Sweetwater, where it has secured deposits of rock and earthy gypsum.

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GYPSUM PRODUCED AND MARKETED IN THE UNITED STATES[1]

Year.	Sold Without Calcining.											
	For Portland Cement.			As Land Plaster.			For Other Purposes.			Total.		
	Quantity, Short Tons.	Value.	Average Price per Ton.	Quantity, Short Tons.	Value.	Average Price per Ton.	Quantity, Short Tons.	Value.	Average Price per Ton.	Quantity, Short Tons.	Value.	Average Price per Ton.
1915	(a)406,393	(a) 528,161	$1.30	69,256	$122,714	$1.77	.....	.....	.....	475,649	$650,875	$1.37
1916	(a)454,112	(a) 607,995	1.34	81,879	176,136	2.04	11,128	$15,299	$1.37	547,119	790,430	1.44
1917	(a)526,881	(a) 867,123	1.65	884,366	230,808	2.74	12,748	26,439	2.07	623,995	1,124,370	1.80
1918	(a)403,635	(a) 974,283	2.41	64,572	255,716	3.96	1,986	6,553	3.30	470,192	1,236,552	2.63
1919	(a)470,267	(a)1,332,637	2.83	39,978	185,566	4.64	(a)	(a)	.....	510,245	1,518,203	2.98
1920	(a)541,901	(a)1,941,057	3.58	107,443	557,925	5.19	19,916	66,213	3.32	669,260	2,565,195	3.83

Year.	Sold Calcined.														
	As Plaster of Paris, Wall Plaster, Keene's Cement, etc.			For Dental Plaster.			To Glass Factories.			As Boards, Tile, and Blocks, and for Other Purposes.			Total.		
	Quantity, Short Tons.	Value.	Average Price per Ton.	Quantity, Short Tons.	Value.	Average Price per Ton.	Quantity, Short Tons.	Value.	Average Price per Ton.	Quantity, Short Tons.	Value.	Average Price per Ton.	Quantity, Short Tons.	Value.	Average Price per Ton.
1915	1,520,308	$5,776,826	$3.80	534	$2,376	$4.45	11,861	$26,620	$2.25	81,017	$140,196	$1.73	1,613,720	$5,946,018	$3.68
1916	1,677,081	6,884,960	4.11	661	8,766	13.26	11,537	28,839	2.50	116,535	246,037	2.11	1,805,814	7,168,602	3.97
1917	1,531,535	8,873,176	5.79	991	7,672	7.74	13,808	72,558	5.25	131,056	1,038,676	7.93	1,677,390	9,992,082	5.96
1918	1,174,359	8,483,633	7.22	(b)	(b)	.....	13,467	84,928	.626	(b)140,343	1,665,741	11.88	1,328,269	10,234,302	7.70
1919	1,393,141	11,809,624	8.48	(b)	(b)	.....	14,677	96,561	6.58	(b)188,202	2,303,519	12.24	1,596,020	14,209,704	8.90
1920	1,578,360	15,723,372	9.96	1,731	27,440	15.85	15,637	125,441	8.02	308,756	6,091,617	19.73	1,904,484	21,967,870	11.53

[1] R. W. Stone, U. S. Geol. Surv.
(a) A small quantity of paint material included with gypsum sold for Portland cement.
(b) Some dental plaster included with boards, tile, etc.

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Gypsum in Foreign Countries

Canada.[1]—The production of gypsum during 1921 showed a decline from the quantity produced during the preceding year, totaling 357,183 short tons valued at $1,725,730, as against 429,144 tons valued at $1,893,991 in 1920.

Nova Scotia was the largest producer of gypsum in Canada, producing 191,519 tons valued at $412,295. By provinces the production for the remainder of the country was as follows: Ontario, 84,765 tons valued at $433,053; Manitoba, 40,859 tons valued at $480,282; New Brunswick, 40,000 tons valued at $400,000; and British Columbia, 40 tons valued at $100.

The statistics collected showed that 410,193 tons was mined during the year, of which 92,024 tons was calcined. The exports of gypsum or plaster in the crude form during 1921 were 230,011 tons valued at $417,502, and gypsum ground 3303 tons valued at $56,954.

The imports of gypsum and plaster of Paris during the same period amounted to 2061 tons valued at $41,377.

PRODUCTION OF CRUDE GYPSUM IN THE PRINCIPAL COUNTRIES (a)
(In metric tons)

Year.	Algeria. (b)	Canada. (g)	France. (b)	Germany. (c)		Greece.	India.	United Kingdom.	United States.
				Baden.	Bavaria.				
1903	41,550	285,242	1,998,804	29,423	30,894	94	(d)	223,426	945,286
1904	48,375	309,133	1,957,802	26,984	22,766	393	3,937	237,749	853,546
1905	34,743	395,341	1,378,145	28,823	46,247	185	4,877	259,596	982,625
1906	27,950	378,904	1,377,429	25,643	50,763	70	(e) 5,000	228,627	1,397,480
1907	26,400	431,286	1,316,567	29,153	48,975	70	(e) 5,000	239,285	1,564,061
1908	25,500	346,436	1,750,562	35,217	51,314	*Nil.*	(e) 5,000	231,980	1,694,155
1909	36,250	398,290	1,655,672	36,621	51,630	191	17,588	242,832	(f) 2,042,286
1910	60,625	481,941	1,980,804	41,078	54,397	249	13,759	259,648	(f) 2,158,756
1911	61,502	470,381	2,110,520	42,408	60,390	1,263	11,115	281,111	(f) 2,112,770
1912	54,414	524,892	2,150,900	51,777	57,114	127	21,383	247,724	(f) 2,269,290
1913	50,413	577,442	1,726,379	49,767	.....	2,245	25,362	242,341	(f) 2,357,752
1914	.....	463,375	.....	.....	32,993	639	22,639	269,637	(f) 2,247,246
1915	.....	430,752	.....	.....	28,459	1,648	22,926	251,209	(f) 2,220,458
1916	.....	311,092	.....	.....	26,124	356	16,826	222,814	(f) 2,500,815
1917	.....	305,120	.....	.....	21,035	44	16,952	175,800	(f) 2,446,016
1918	.....	138,155	.....	.....	23,330	.....	17,016	181,612	(f) 1,865,622
1919	.....	278,454	.....	.....	33,692	.....	28,774	223,545	(f) 2,223,547
1920	.....	389,319	.....	.....	.....	.....	34,091	291,598	(f) 2,838,758

(a) From official reports of the respective countries, except the statistics for the United States (b) A part of the product is reported as plaster of Paris. In converting this into crude gypsum it has been assumed that the loss by calcination is 20 per cent. (c) Prussia is a large producer of gypsum, but there are no complete statistics available. The output in 1910 was 22,042 tons. (d) Statistics not available. (e) Estimated. (f) U. S. Geol. Surv. (g) Tonnage shipped. See detailed statement on Canada for total tonnage produced.

Ireland.—Five bores sunk at Knocknacran, about 2 miles from Carrickmacross, in County Monaghan, Ireland, early in 1921, proved the existence of a large deposit of gypsum, according to Consul F. T. F. Dumont in *Commerce Reports.* Bores put down at Lisaboe, County Meath, in prospecting for coal or other minerals disclosed a body of gypsum estimated by an expert of the Department of Geology at 1,000,000

[1] Prelim. Rept. Min. Prod. of Canada, 1921, Dominion Bur. of Statistics.

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tons. The Farney Development Co., Ltd., has secured the mineral rights over this property and is building a factory capable of producing 25 tons of plaster of Paris a day. About 1000 tons of high-grade gypsum has been quarried and is ready for manufacturing. Some large blocks of beautifully colored Irish alabaster have also been secured, and it is reported that the entire output of this product will be taken by the Irish Marble Co., of Kilkenny, for disposal among its customers.

The Farney Development Co. put into operation this new plaster works late in 1921 at Kingscourt, some 50 miles from Dublin. The company has acquired possession of nearly 1500 acres of gypsum land and mineral rights over 2000 additional acres. It will develop gypsum production for the manufacture of plaster of Paris and the quarrying of alabaster.[1]

Prof. Henry J. Seymour, professor of geology in the National University of Ireland, states that the minerals consist of gypsum and brick-clay of excellent quality, with some sand and gravel. The most important mineral is the gypsum, which appears to underlie the whole of the property. Its presence has been ascertained not only by pits and borings but by quarrying, and in the excavations for the railway. Beds of gypsum varying in thickness from 3½ to 70 ft. have been met with in the eight borings made. The upper beds of gypsum, extending over some 15 acres, are sufficiently near the surface to admit of economic working by open quarrying, some portions, indeed, outcropping along the railway line. The greater portion consists of compact crystalline gypsum practically free from coloring matter, and should burn to a white product. The less pure beds should be readily salable for agricultural uses.

Australia.—A report by R. Lockhart Jack, of the Geological Survey of South Australia,[2] describes gypsum deposits that are yearly becoming more important from the standpoint of output, and supplements the earlier descriptions of Winterbottom.[3]

In this report the following table showing production, exports, and imports to 1919 is given, the data for 1920 and 1921 having been added.

	Australian Output of Gypsum.		South Australian Output of Gypsum.		Australian Export of Gypsum and Plaster of Paris.		Australian Imports of Calcined Gypsum.	
	Long Tons.	£	Long Tons.	£	Long Tons.	£	Long Tons.	£
1913	8,826	7,725	7,150	5,362	560	878	12,383	41,157
1914	17,353	13,131	16,726	12,207	522	1,505	18,942	33,450
1915	20,520	18,033	19,900	17,413	638	1,577	47	185
1916	22,224	19,678	20,371	17,825	12,810	15,396	16	54
1917	13,963	12,514	12,776	11,179	7,991	10,116	18	118
1918	32,744	28,446	32,013	28,012	7,085	8,204	16	141
1919	(a)26,000	(a)19,200	25,216	18,725	4,706	8,030	5	73
1920	.....	.....	40,192	31,604	(b)5,765	(b)10,710	(b)13	(b)103
1921	.....	.....	34,383	29,427	.....	.....	.....	.....

(a) Estimated. (b) Fiscal years ending June 30.

[1] *Rock Products*, Jan. 14, 1922.

[2] Department of Mines, Geol. Surv. of South Australia, Bulletin No. 8, Part II (1921).

[3] "Gypsum and Plaster of Paris," Dept. of Chemistry, South Australia, Bulletin No. 7 (1917).

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IRON AND STEEL

By Edwin F. Cone

The year 1921 will be pointed to for many years as one which suffered a depression almost unparalleled. The close of 1920 witnessed decided signs of the approach of this slump, and as the year 1921 advanced its seriousness grew until by July and August operations were at the lowest point in the history of the industry.

The same is true of exports of iron and steel. The early months of the year reported heavy sales to foreign countries, which gradually declined to very low figures by July and August.

Liquidation in prices was another feature of the year's progress. The high levels reached in 1920 were slowly obliterated until by the close of 1921 quotations for pig iron and steel products had been completely liquidated so far as war prices are concerned, due regard being taken for the increased cost of labor and transportation.

A gradual recovery in pig-iron and steel production took place in the latter part of the year, but by the end of the year this was still small as compared with present capacity and with pre-war outputs.

Imports and Exports.—The imports and exports of iron and steel are tabulated below. Exports were much lower in 1921 than in 1920 on all products except pipes and fittings. The total for 1921 was 2,007,319 gross tons against 4,960,851 tons in 1920 and 4,483,483 tons in 1919.

UNITED STATES EXPORTS OF DOMESTIC IRON AND STEEL
(In tons of 2240 lb.)

	1914.	1915.	1916.	1917.	1918.	1919.	1920.	1921.
Pig iron	114,423	224,509	612,241	656,220	269,575	321,261	321,261	28,305
Billets, blooms, etc.	50,496	560,704	1,504,562	2,017,113	1,786,289	258,424	216,873	10,363
Bars, steel	128,228	465,720	848,479	682,798	642,516	554,211	624,587	188,595
Rails	174,680	391,379	540,349	512,669	453,944	652,449	594,634	322,107
Sheets and plates	280,090	419,637	515,462	831,736	824,886	1,272,657	1,141,371	607,249
Structural steel	182,395	232,139	300,594	294,150	232,729	360,787	493,655	297,022
Wire	180,395	473,583	683,025	393,825	392,305	291,662	325,142	99,311
Wire-rods	61,853	165,014	158,284	181,975	148,523	118,009	116,775	18,506
Nails and spikes	49,622	118,349	191,131	159,978	104,311	129,233	121,606	42,059
Pipes and fittings	199,618	176,884	228,573	209,184	145,943	375,535	353,590	393,802

Total imports in 1921 were 118,304 long tons, which compare with 417,581 tons in 1920 and with 322,261 tons in 1919. The 1920 total was the largest in any year from 1913 to 1920.

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UNITED STATES IMPORTS OF IRON AND STEEL
(In tons of 2240 lb.)

	1913.	1914.	1915.	1916.	1917.	1918.	1919.	1920.	1921.
Pig iron	165,450	138,903	89,836	125,349	76,786	34,711	101,665	196,364	44,516
Billets, blooms, etc	26,675	49,188	14,998	26,142	44,195	41,072	16,268	26,022	6,988
Scrap iron and steel	44,154	34,849	79,982	116,039	180,034	63,730	177,293	140,645	41,469
Bars, iron	28,243	15,015	8,474	7,701	2,240	1,469	1,940	4,987	1,913
Rails	10,408	22,571	78,525	26,299	9,263	8,705	17,008	45,684	22,048
Wire-rods	16,097	6,954	5,316	4,130	1,006	7,677	342	5,847	916
Tin-plate	20,680	15,411	2,350	1,007	124	32	242	400	454

Iron Ore

The iron-ore output of the United States in 1921 was 29,547,000 gross tons, against 67,604,465 tons in 1920 and 60,466,000 tons in 1919, according to the figures compiled by Ernest F. Burchard of the United States Geological Survey. This represents a decrease in 1921 of about 54 per cent.

The shipments of ore from the mines in 1921 are estimated at 27,009,000 gross tons, valued at $89,688,000, a decrease in quantity of 61 per cent. and in value of nearly 69 per cent. as compared with 1920. The average selling value of the ore per gross ton at the mines for the United States in 1921 was $3.32; in 1920 it was $4.18. The stocks of iron ore at the mines, mainly in Michigan and Minnesota, increased from 11,379,000 tons in 1920 to 13,872,000 tons in 1921, or 22 per cent.

The production of iron ore in 1921 was the lowest since 1904, when 27,644,330 tons was mined. These preliminary figures are based on returns from producers of nearly 97 per cent. of the normal output of iron ore and were supplemented by estimates covering the remainder of the output.

The Lake Superior district produced 86 per cent. of the iron ore mined and shipped in 1921. In this district a total of 23,155,000 gross tons was mined and 22,300,726 tons was shipped, a decrease of 62 per cent. as compared with 1920.

The ore shipped from the Lake Superior district in 1921 was valued at $81,091,000, a decrease of about 68 per cent. The mines in Minnesota furnished 78 per cent. of the total iron ore shipped from the Lake Superior district and 67 per cent. of the total of the United States. The average selling price of the ore at the mines in the Lake Superior district in 1921 was $3.50 a ton; in 1920 it was $4.25. The stocks of iron ore in this district apparently increased from 10,366,738 gross tons in 1920 to about 12,575,000 tons in 1921, or 21 per cent. The shipments of iron ore by boat from the Lake Superior district in 1921, according to figures compiled by the Lake Superior Iron Ore Association, amounted to 22,300,726 gross tons, a decrease of 62 per cent. as compared with 1920. The Southeastern

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States, which form the second-largest iron-ore producing area, including the Birmingham[1] and Chattanooga districts, mined 3,022,000 gross tons of iron ore in 1921, a decrease of 55 per cent. as compared with 1920. The shipments of ore to blast-furnaces from these states in 1921 amounted to 2,946,000 gross tons, valued at $6,343,000, a decrease in quantity of 56 per cent. and in value of 67 per cent. as compared with the previous year. The average selling value of the ore in these states in 1920 was $2.15 a ton; in 1920 it was $2.88.

In the Northeastern States—New Jersey, New York and Pennsylvania—there was mined 668,000 gross tons of iron ore in 1921, a decrease of 68 per cent., and there was shipped 444,000 gross tons, a decrease of 79 per cent. The average selling value of the ore in these States was $2.88 a ton as against $4.90 in 1920.

IRON ORE MINED IN THE UNITED STATES IN GROSS TONS (a)

State.	1917.	1918.	1919.	1920.	1921.
Minnesota	44,595,232	41,953,969	35,767,000	39,453,173	18,093,000
Michigan	7,868,601	16,899,341	15,471,000	17,510,742	7,054,000
Alabama	7,037,707	5,754,624	5,034,000	5,894,011	2,927,000
Wisconsin	1,20.,235	1,089,351	888,000	981,134	247,000
New York	1,30 ,317	906,179	858,000	920,009	470,000
Wyoming	543,846	447,884	.....	.....	.....
New Jersey	489,943	423,525	409,000	431,567	58,000
Pennsylvania	546,700	522,600	547,000	734,383	140,000
Virginia	499,903	414,048	288,000		
Tennessee	508,529	408,954	271,000	872,783	95,000
Georgia	226,630	264,602	80,000		
North Carolina	90,997	108,332	67,000		
Missouri	38,908	72,708	.....	.....	.....
New Mexico	237,221	268,666	.....	.....	.....
Colorado	*	7,850	.....	.....	.....
Connecticut	*	12,130	.....	.....	.....
Maryland	11,830	8,081	.....	.....	.....
Nevada	1,010	20,303	.....	.....	.....
Massachusetts	10,000	8,450	.....	.....	.....
Ohio	.....	.....	.....	.....	.....
California	2,207	3,107	.....	.....	.....
Kentucky	.....	.....	.....	.....	.....
West Virginia	4,632	.....	.....	.....	.....
Iowa	22,612	7,052	.....	.....	.....
Utah	48,058	52,722	.....	.....	.....
Arkansas	40	.....	.....	.....	.....
Other states	27,693	2,800	786,000	806,663	463,000
Totals	75,288,851	69,658,278	60,466,000	67,604,465	29,547,000

(a) U. S. Geol. Surv.
* Less than three producers in Colorado and Connecticut in 1917, and permission was not granted to publish state totals.

Lake Superior District.[1]—Lake shipments in 1921 totaled 22,300,726 long tons as compared with 58,527,226 tons in 1920, a decrease of 36,226,500 tons. The total all-rail movement was 498,351 tons against 1,884,346 tons in 1920. The total iron ore shipped from the entire district in 1921 was therefore 22,799,077 tons, or 43,859,389 tons less than the record total in 1916 of 66,658,466 tons. The record of these two years repre-

[1] *Iron Tr. Rev.*, Feb. 2, 1922.

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sents the two extremes in the effect of the war and its aftermath. The 1921 total was the smallest in 17 years. Following is the record of all-rail shipments since 1912, in gross tons of ore:

1912	785,769	1917	1,938,102
1913	876,638	1918	1,679,440
1914	707,829	1919	1,369,256
1915	953,947	1920	1,883,251
1916	1,924,268	1921	498,351

Four-fifths of all the iron ore that has been shipped from the Lake Superior district has been forwarded to the blast-furnaces since 1901. In this period the average yearly shipment has been 40,870,843 tons. The tonnage of 1921 was 44 per cent. below this yearly average.

The Lake Superior district now has shipped 1,029,756,566 tons of iron ore. Of this amount 574,186,604 tons was from the Mesabi range, which was opened in 1892. The three large ranges of Michigan: Marquette, with a record of 73,553 tons prior to 1854, Menominee, opened in 1877, and the Gogebic, shipping since 1884, all combined have forwarded only 393,920,971 tons.

The operations of the independent mining interests in the Lake Superior district may be gaged by comparison with those of the Oliver Iron Mining Co., subsidiary of the United States Steel Corporation. This company's report shows that the latter shipped 14,056,759 tons of ore from the Lake Superior district in 1921, as compared with 24,936,073 tons in 1920. The total in 1921 was 61.65 per cent. of all the ore shipped, while the general average for the preceding 12 years was about 46.50 per cent. The company's proportion of the total last year was the largest it ever attained; while the amount of ore it shipped receded to practically the same figure as of 1908—14,123,957 tons.

The following table shows the shipments and percentages of the Oliver Iron Mining Co., the Steel Corporation's mining organization, for each of the last 10 years:

Year.	Gross Tons.	Percentage.
1912	23,845,363	49.46
1913	24,502,244	49.06
1914	16,039,654	49.01
1915	22,518,613	47.63
1916	31,673,131	47.52
1917	28,571,977	44.34
1918	26,178,782	41.66
1919	22,069,148	45.20
1920	24,936,073	41.28
1921	14,056,759	61.65

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PRODUCTION OF IRON ORE IN LAKE SUPERIOR DISTRICT
(In tons of 2240 lb.)

Year.	Tonnage.	Year.	Tonnage.	Year.	Tonnage.	Year.	Tonnage.	Year.	Tonnage.
1855...	1,449	1880..	1,948,334	1905..	34,353,456	1914..	33,629,613	1919..	47,177,395
1860...	114,401	1885..	2,466,642	1910..	43,442,397	1915..	46,994,254	1920..	58,527,226
1865...	193,758	1890..	9,003,725	1911..	32,793,120	1916..	64,734,198	1921..	22,300,726
1870...	809,507	1895..	10,429,037	1912..	46,483,798	1917..	62,498,901	.....	.....
1875...	881,166	1900..	19,059,393	1913..	52,518,158	1918..	61,156,732	.....	.....

SHIPMENTS OF IRON ORE FROM LAKE SUPERIOR DISTRICTS
(In tons of 2240 lb.)

Range.	1916.	1917.	1918.	1919.	1920.	1921.
Marquette.....	5,396,007	4,874,150	4,354,297	2,992,212	4,608,323	1,116,900
Menominee.....	6,364,363	6,045,750	6,378,698	4,442,868	6,562,106	1,584,404
Gogebic.....	8,489,685	7,981,684	7,936,701	6,230,839	8,763,332	2,336,493
Vermillion.....	1,947,200	1,530,692	1,192,908	929,049	1,007,435	869,313
Mesabi.....	42,525,612	41,445,211	40,396,711	31,997,699	37,149,277	16,350,696
Baraboo.....	1,716,218	136,632	98,057	92,819	129,571	52,709
Cuyuna	219,381	2,422,884	2,478,000	1,861,165	1,191,528	488,562
Total.....	66,658,466	64,437,003	62,836,172	48,546,651	60,410,477	22,799,077

The record for 1921 shows that the Mesabi range mines shipped 16,350,696 tons. The number of mines which shipped was 71, and the average amount shipped by each 230,291 tons. In 1920, the number which shipped ore was 114.

The record of 1921 shows that 71 mines on the Mesabi range shipped the total, 16,350,696 tons, as compared with 114 mines which shipped 37,149,277 tons in 1920. Twenty-eight mines on the Menominee range shipped ore in 1921 as compared with 39 in 1920, and the amount was 1,584,404 tons as compared with 6,562,106 tons in 1920. The number of mines on the Marquette range which shipped in 1921 was 18, and in 1920, 27; while the tonnage was 1,116,900 in 1921 and 4,608,323 in 1920. The Gogebic mines in 1921 numbered 19, as compared with 25 in the previous year, and the tonnage shipped in 1921 was 2,336,493, as compared with 8,763,332. The Cuyuna range suffered the greatest slump of all. Only eight mines shipped in 1921 as compared with 24 in 1920, and the tonnage was only 488,562, as against 2,191,528 in 1920. The Vermillion range showed more steadiness: Four mines shipped 869,313 tons in 1921, as compared with seven which shipped 1,007,435 tons in 1920.

Including the mine at Mayville, Wis., operated by the Steel & Tube Co. of America, and which produced 52,709 tons of ore in 1921, the total number of mines in the Lake Superior district from which ore was shipped in 1921 was 149. In 1920 the number was 237; in 1919, 240; and in 1918, 284. In 1916, the year of the maximum shipment, the number was 233.

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Lake shipments in 1921 totaled 22,300,726 tons, as compared with 58,527,226 tons in 1920, and the all-rail shipments amounted to 498,351 tons, as against 1,884,346 tons in 1920.

The dearth of operations is reflected in the fact that only four mines in the Lake Superior district shipped 1,000,000 tons or more each in 1921, compared with seven in 1920 and 1919, and 12 in 1918. The mines with this record in 1921 are the Canisteo, 1,128,925 tons; Hull-Rust, 3,719,256 tons; Missabe Mountain, 1,816,178 tons; and the Norrie group, 1,015,202 tons. All four are operated by the Oliver Iron Mining Co. Some of the other mines which made large shipments in 1921 are: Dunwoody, 488,485 tons; Kerr, 547,043 tons; Leonidas, 449,881 tons; and Spruce, 815,307 tons, all of the foregoing mines being part of the Mesabi range. The largest shipment made by any one mine on the Menominee range was from the Chapin, 279,134 tons, by the Oliver Iron Mining Co. The largest on the Marquette was 201,030 tons, from the Lake Superior mine, operated by the Oliver company. The Norrie group of the Gogebic range, also operated by the same company, forwarded the largest tonnage from that range, 1,015,202 tons. The largest shipper on the Cuyuna was the Armour No. 2, with 214,040 tons.

The Adams mine, Mesabi range, which in 1920 shipped 784,481 tons, reduced to the point of 102,293 tons in 1921. The Fayal, Mesabi range, fell from 1,045,664 tons to 278,974 tons; Hartley-Burt-Palmer from 1,249,736 tons to 97,371 tons; Mahoning from 1,720,538 tons to 303,019. On the Marquette range the Cleveland-Cliffs group, which in 1920 forwarded 651,004 tons, reduced its total to 104,160 in 1921.

The Hull-Rust pit at Hibbing, Minn., continues to be the largest individual shipper in the Lake Superior district. The magnitude of production may be gaged by the fact that its tonnage of 1921, namely 3,719,256, exceeded the entire output on the Menominee range by 2,134,852 tons. It exceeded the Marquette's record by 2,602,356 tons; and it even surpassed the tonnage of the Gogebic range by 1,382,763. It nearly equaled shipments from both the Marquette and Menominee ranges.

Only one new mine was opened in the Lakes district in 1921, and this, curiously enough, on the Cuyuna range, which suffered more severely from the slump in business than any other producing area. The Maroco of the Marquette Ore Co. developed into a shipper of washed concentrates, forwarding 6596 tons during the season, the bulk all-rail to St. Louis.

On the Canadian side, the Algoma Steel Co. shipped 52,442 tons from the Magpie mine, and 79 tons was shipped all-rail from Moose Mountain, the mine of the Moose Mountain, Ltd.

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Detailing of the facts of the Lake Superior ore trade in 1921, while necessary for continuity, is like retelling an old, sad story which had best be forgotten; but even while the facts are established and the story written there are noted here and there signs of activity and promise of more life. The slate is scarcely covered when time sweeps aside the figures and a new record is begun; a record which in 1922 gives every indication of being far superior to that of 1921.

SHIPMENTS BY PORTS AND ALL-RAIL
(Gross tons)

	1916.	1917.	1918.	1919.	1920.	1921.
Escanaba	7,457,444	7,156,854	6,774,969	4,963,358	7,361,070	1,806,656
Marquette	3,858,092	3,207,145	3,457,054	2,132,985	3,415,108	786,946
Ashland	8,057,814	7,597,841	7,565,606	5,915,383	8,180,852	2,264,705
Two Harbors	10,735,853	9,990,901	8,723,472	6,424,545	9,278,464	3,286,338
Superior	12,787,046	13,978,741	14,068,341	10,919,965	14,812,398	4,991,278
Duluth	21,837,949	20,567,419	20,567,288	16,821,209	15,479,334	9,164,803
Total by lake	64,734,198	62,498,901	61,156,782	47,177,395	58,527,226	22,300,726
Total by rail	1,924,268	1,938,102	1,679,440	1,635,127	1,883,251	498,351
Total	66,658,466	64,437,003	62,836,082	48,812,522	60,410,477	22,799,077

The following shows the average shipments from all the mines on the seven leading ranges.

LEADING SHIPPERS OF THE LAKE SUPERIOR DISTRICT

	1917.	1918.	1919.	1920.	1921.
Mesabi:					
Burt	692,017	747,968	683,205	602,726	223,316
Canisteo	1,643,226	1,426,399	1,255,668	1,127,735	1,128,925
Fayal	2,037,705	1,366,083	990,458	1,045,664	278,974
Hull-Rust	6,461,443	5,452,585	5,100,555	6,994,728	3,719,256
Leonard	305,537	737,209	236,358	389,982	194,633
Leonidas	795,826	656,735	293,634	555,337	449,881
Mahoning	2,524,110	2,024,595	1,237,168	1,720,538	303,019
Morris	1,605,701	1,044,558	799,047	948,226	126,218
Sauntry-Alpena	596,049	531,427	422,825	190,652	.....
Sellers	1,575,057	865,070	265,925	176,761	280,850
Menominee:					
Bristol	188,907	245,151	58,183	368,479	13,555
Caspian	411,705	346,028	315,029	421,822	.....
Chapin	682,349	705,803	524,679	850,316	279,134
Marquette:					
Cleveland-Cliffs	946,410	1,050,147	437,475	651,004	.....
Negaunee	573,760	501,965	424,112	550,297	184,222
Gogebic:					
Montreal	458,658	298,896	319,598	306,660	.....
Newport	1,003,229	1,041,697	915,959	1,155,149	99,404
Norrie Group	1,646,606	1,550,802	1,335,468	1,610,128	1,015,202
Wakefield	1,144,411	1,130,432	595,944	978,694	.....
Vermillion:					
Pioneer	352,497	260,516	376,758	441,017	503,392
Zenith	382,666	243,093	124,721	200,077	149,427
Cuyuna:					
Armour No. 2	273,812	246,362	231,550	286,186	214,040
Pennington	165,895	164,269	100,981	144,403	.....
Mayville-Baraboo:					
Mayville	93,997	88,812	92,819	78,544	52,709

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The following table shows the average shipments of all mines on the six leading ranges and of the whole Lake Superior district for 1916–1921.

AVERAGE MINE SHIPMENTS

	1916.	1917.	1918.	1919.	1920.	1921.
Mesabi	397,436	339,715	299,235	278,240	325,780	230,291
Vermillion	243,400	191,336	132,545	132,721	143,919	217,428
Gogebic	339,585	295,618	294,952	249,221	350,533	122,973
Marquette	119,852	194,966	131,946	115,085	170,678	62,050
Menominee	141,430	147,457	130,177	113,919	168,258	56,621
Cuyuna	95,345	115,375	85,476	71,533	95,236	61,070
Lake Superior district	286,087	261,939	222,475	203,385	254,896	153,074

Imports.—The following table shows the imports of iron ore, in gross tons:

FOREIGN ORE IMPORTS DURING LAST SEVEN YEARS

Country from Which Exported.	1915.	1916.	1917.	1918.	1919.	1920.	1921.
Cuba	831,618	716,571	546,069	632,442	321,753	889 852	123,222
Sweden	204,632	212,063	63,715	.....	61,540	63,861	130,832
Spain	42,092	161,422	152,713	38 385	63,737	69,915	5,602
Chile	146,000	.....	.....	.....	.....	.....	.....
Canada	84,124	136,835	178,785	115,354	12,383	34,084	4,213
Africa	22,000	.....	.....	.....	.....	.....	.....
Other countries	10,815	98,845	30,381	1,287	17,048	210,824	51,889
	1,341,281	1,325,736	971,663	787,468	476,461	1,268,536	315,768

Exports.—Exports of iron ore from the United States in 1921 amounted to only 440,100 gross tons, as compared with 1,145,037 tons in 1920 and 996,569 tons in 1919.

Iron and Steel Market

The following review[1] covers the general market conditions during the year in the industry as a whole.

The iron and steel industry entered 1921 well persuaded that the depression that came upon it three months before the end of 1920 would grow more acute in the new year. Yet it is truth to say that no prophecy made at the beginning of 1921 went so deep into depression as both prices and production went, as the result of the year's developments.

Prices declined steadily throughout the year, with an occasional eddy unrelated to the general trend, and the plotted curves for rolled steel are all at high point in January and at low point in December. The production curve is different. Its high point is in January, but its low point is in July, while December is about half way between the two.

Just as in the second half of 1919 and the greater part of 1920 most manufacturers believed that the war reckoning had been dodged, because it did not come as soon as they expected, so in the early months of the present depression there was a belief that the demand for iron and steel dropped off so precipitously in the fall of 1920 that some rebound was inevitable. The spring of 1921 was the time generally set for

[1] *Iron Age*, Jan. 5, 1922.

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renewed buying, and the theory was that as restriction in output, particularly in pig iron, had been drastic, there might be some stiffening in prices along with the revival in demand. All such hopes were disappointed.

At the beginning of April it was said in *The Iron Age's* market summary: "Production [of pig iron] to-day is the smallest on record in proportion to the country's capacity." The same statement could have been made in succession at the beginning of May, June, July and August. But in August the turn came and for four months there was a succession of increases in output. Steel-ingot production likewise was at low point in July.

The one thing in the record of 1921 as a steel year that stands out above all else, and that was continually a marvel, was the way in which consumers got along without going to the mills. There was much more steel in the country in the hands of jobbers, manufacturing consumers and others than had been thought. The country never got along before on a 38-per cent. operation of its steel capacity and it would not have done so last year but for using up to the last ton what was carried over from 1920. Thus the effort of consumers in all lines to reduce their steel inventory to the lowest point dominated mill operations. As prices steadily declined resort was had to every expedient to avoid drawing on the mills for fresh supplies. Railroads shipped steel across the country from one repair shop that had fair stocks to another that had little. Jobbers in iron and steel traded with competing jobbers, shipping sizes and forms in which they were overstocked in exchange for sizes and forms of which they had little. Steel companies at times shipped from their warehouses at mill prices rather than start up a mill for a meager rolling on which delivery was due.

Blast-furnace yards were full of ore bought at the high prices of 1920. Throughout the year such stocks were a heavier and heavier incubus on the ore and pig-iron markets. As illustrating the inclination of the whole trade, particularly in the early months of the year, to take the most hopeful view possible of the future, the estimate was common at the end of March that "less than 40,000,000 tons of Lake Superior ore will be shipped this season," seeing that fully 31,000,000 tons was then in furnace yards and on docks. "Less than 40,000,000 tons" was quite correct! But there was no idea on Mar. 31 that the season's movement down the lakes would turn out to be so little as 22,300,000 tons.

An unprecedented thing was added to all the other influences at work to restrict demand for steel. Along in the second quarter of the year large manufacturing consumers turned jobbers, selling off bars, plates structural shapes, or whatever they had on hand, at less than warehouse prices. Many of the Steel Corporation's contracts of 1920, taken at much below prevailing prices, were written down as firm orders and the buyers took the deliveries when due. In some cases they could not use the steel, but generally the reselling was prompted by the belief that it could be replaced at lower prices.

Steel Corporation and "Independent" Prices.—The low prices maintained by the Steel Corporation in 1919 and 1920, ranging from $10 to $30 per ton below those of independent steel companies in different products, extended their influence into 1921—but not for long. The year opened with the Steel Corporation operating at 85 to 90 per cent. of capacity. Independent companies, which for many months in 1920 had sought prompt rather than contract business, had little work ahead and early in January ran at less than half the Steel Corporation's rate. Later in that month independent mills operated at but 20 to 30 per cent. of capacity. Some followed the plan of shutting down certain mills altogether, then after two weeks or so starting up to take care of orders that had come in.

The difference in the position of the Steel Corporation and the independents early

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in the year will appear from the fact that in December, 1920, the latter curtailed pig-iron production by blowing out 19 furnaces, whereas the Steel Corporation had three more furnaces at work on Jan. 1 than on Dec. 1. In January the independents blew out nine more furnaces while the corporation blew in one. In February, however, the Steel Corporation was made to feel the effects of the universal contraction, its list of active blast-furnaces suffering a net loss of 15 in the month.

At the beginning of the year the Steel Corporation was still adhering to the so-called Industrial Board prices of Mar. 21, 1919. But only a few weeks had passed before the independents went lower. In the first week of February the Midvale Steel & Ordnance Co. announced that it would quote prices low enough to bring business to its mills, some of which had been shut down since early December. Cuts of $5 per ton below the Steel Corporation schedules came promptly, the products chiefly affected being plates, shapes and bars. The decline went on for several weeks, the Steel Corporation meanwhile maintaining the prices to which it had adhered for about two years.

By Apr. 1 plates had declined from 2.65 cts. on Jan. 1 to 2 cts., beams from 2.45 cts. to 2 cts. and bars from 2.35 cts. to 2 cts. On Apr. 12 the Steel Corporation announced that it had decided to make substantial reductions, putting bars at 2.10 cts. and plates and shapes at 2.20 cts. Billets were reduced from $38.50 to $37, wire rods from $52 to $48 and tin-plates from $7 to $6.25 per box. At the same time independent companies, which had been selling below these prices, advanced their quotations to those announced by the Steel Corporation. It was apparent in May that these prices were not holding, some plate mills having made a 2-ct. price, while bars were sold at 1.90 cts. Pittsburgh. These price cuts did not increase the volume of business, there being no evidence of a stabilizing influence.

On July 5 the Bethlehem Steel Co. announced reductions amounting to $4 per ton for bars, plates, shapes, billets, skelp, sheet bars and blue annealed sheets, $5 for black and galvanized sheets, and $10 for tin-plate. On some products this announcement merely recorded what the market already had done. In mid-July aggressive competition between the Steel Corporation and independent steel producers developed in the Chicago market, Pittsburgh basing having gone by the board in that district.

Through the remainder of the year prices kept on declining. One small countercurrent was started by an advance of $2 to $3 per ton in wire products, made by the Steel Corporation, effective Sept. 10. The real effect of this advance was to bring a large amount of business on its books at prices previously prevailing, which were $2.75 per keg for wire nails and $2.50 per 100 lb. for plain wire. While considerable business was done later at the advanced prices of $2.90 for nails and $2.60 for plain wire, it turned out that these prices were not really enforced. Later in the year there was considerable cutting in wire products and on Dec. 21 the Steel Corporation announced formal reductions to $2.50 for wire nails and $2.25 for plain wire.

There was a jog in the pig-iron price line, most noticeable in the Eastern market. Low point was reached in all pig-iron markets in August, and in some a slight turn upward came in September, lasting through October. In November prices began falling away again and the decline continued through the year.

Uneconomical Operation.—Throughout the year steel companies were constantly at work to get costs down. Naturally wages were reduced, as will be referred to later. But economies in operation were enforced, such as were not possible in the strain for output which marked most of the months of 1920. Crews were recast, and in some instances mill foremen were given such general orders as to use five men to do the work formerly done by six. Fuel economy was studied anew, in view of the war wages paid at coal mines and the high freight on coal. New economies were found in the

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use of refractories, lubricants and all other supplies, on which costs had run up beyond all precedent. Per-capita output was increased in some classes of operations. At blast-furnaces accumulated flue-dust piles were made available by sintering, replacing in some cases considerable percentages of high-priced ore in blast-furnace mixtures.

But every effort at economy, even that secured by the easiest and least desirable route of wage cuts, met eventual defeat at the hand of high-unit overhead. All that steel producers had learned of the incomparable value of large tonnages as a divisor into fixed charges had to be forgotten. Small runs, spasmodic starting and stopping of mills, and at all times fractional operation of producing capacity were insuperably baffling. Cases are known in which, rather than start up a mill to make a scheduled delivery, the producer bought the material from a competing company. The latter got the benefit of a longer run, which helped its cost, while steel company No. 1 was able to buy at less than it would have cost it to start its mill.

Sources of Demand.—The railroads are credited with consuming each year a large percentage of the country's steel output. They did not consume much last year, as is told below, but it is to be said in passing that the railroad consumption of steel is always exaggerated in the general thinking. It is doubtful if it has gone above 25 per cent. in any year in the past twenty, apart, possibly, from 1906 and 1907, and commonly it is not above 20 per cent.

Throughout the year it was the constant comment in market reports that in the heavy products—rails, plates, shapes and bars—demand was indifferent. The lighter products did better—wire, sheets and tin-plates. On the whole, there was a good business, particularly in the second half, in wrought pipe. The new oil fields of Texas and the revival in the petroleum market after a period of flatness brought out some good contracts for line pipe.

What saved the day for plate mills, in the small demand from shipyards and car works, was the unusual amount of tank work called for by the oil fields, particularly the Mexia field of Texas. In the second half of the year tank works in the West and Middle West were unusually busy on this account.

New construction, commonly called an index of activity in steel, was held back by excessive labor cost. There was a good deal more house-building throughout the country than was commonly credited. This is established by the fact that foundries making heating-furnace castings ran at a much better rate than others and that radiator companies really had a good year. Manufacturers of sanitary equipment and builders' hardware fared well also. A good deal was done in the erection of schoolhouses and other public buildings, but not much in business structures, and very little in bridges. The bookings of the fabricating companies averaged for the year about one-third of their capacity.

Agricultural-implement warehouses were pretty well stocked with machinery throughout the year, and manufacturers in these lines did little. No large buying of steel from that quarter is to be looked for until the farmer gets on his feet, and that will not be until after the next harvest. The automobile demand was about what was expected of it—considerably less than half that of 1920.

Replenishment demand, after months in which the country had been swept bare of steel in all forms, caused the larger operation of steel works and rolling mills that dates from the early fall of last year.

Railroad buying in 1921 was most disappointing. From early in the year until its end steel producers held to two main hopes, neither of which was realized. One was that the Government's settlement of the railroad claims for losses during the period of control would give them means with which to buy equipment and do track work, thus helping the steel mills in their time of need. The other was that freight-rates would

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be put down and the steel trade relieved in part of the heavy burden of transportation charges nearly double those of pre-war time.

The special hardship of the 40-per cent. rate increase of August, 1920, on the raw material of steel making was put before the carriers time and again. Many of them conceded the force of the argument that there is no parallel in other industries for the hauling, often for long distances, of five tons of raw material for the making of one ton of finished steel product. But the railroad presidents were so engrossed with issues growing out of their relations with the labor unions that they could not take the plight of the steel industry into their thinking. Nor could they be made to see how far any increased buying of steel that might result from lower freight-rates on its raw materials would go in improving their own business.

From time to time predictions of betterment in the steel trade were put out, on the promise of legislation, favored by the administration at Washington, for the funding of $500,000,000 of railroad indebtedness to the Government for property expenditures in the period of control. But this legislation never came through. Various settlements were made on war-time claims of the railroads against the Government, and following these there were belated payments of railroad obligations to the steel mills. Substantial relief to the railroads came in a 12½-per cent. wage reduction on July 1 and in changes in shop rules made by the Railroad Labor Board in December, working savings of many millions of dollars per year.

Out of all the expectations of railroad buying entertained at the opening of the year the actual outcome was far below that of 1920. And 1920 was a year in which the railroads, directly and indirectly, consumed not more than 15 per cent. of the country's steel output. New cars ordered were only a fraction of the 84,000 placed in 1920, being only about 20,000, and locomotives ordered for domestic use were fewer than 250. The repair of 40,000 cars helped in a measure to make up to the mills what they missed in steel for new cars.

Wage Reductions.—In striking contrast with the preceding year, 1921 was not marked by any serious labor troubles, although numerous threats were made, including that of a general railroad strike to be called on Nov. 1. There were many reductions in wages at iron and steel works. As the year came in, cuts of 20 to 25 per cent. went into effect at independent steel mills. The Steel Corporation made its first wage reduction on May 16, amounting to 20 per cent. This reduced common labor from $5.06 to $4.05 per day. Salaries were reduced also. Up to that time the Corporation had adhered to its schedule, announced Feb. 1, 1920, which recorded the ninth advance since Jan. 1, 1916. The Steel Corporation abolished overtime on July 16 and on Aug. 29 made another reduction, bringing the wage of common labor to $3 per day. There was serious unemployment in steel works communities throughout the year. At some eastern Pennsylvania plants the wages of common labor went as low as $2 per 10-hour day, or to the level of 1915. At some Central Western works the rate for common labor declined to 25 cts. per hr. as against 30 cts. at Steel Corporation plants.

An unemployment conference assembled in Washington through the efforts of President Harding and Secretary Hoover adopted various measures to improve the situation and succeeded to some extent.

Federal Trade Commission Cases.—The Federal Trade Commission early in May, by a vote of three to two, issued a complaint in the now famous Pittsburgh price-basing case, setting forth alleged violation of the Clayton anti-trust act. The Steel Corporation filed its answer about a month later and the Government attorneys have been busy since in studying the case, but it is not known when the hearing will be or when a decision may be expected. The complaint is directed against the Steel Cor-

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poration and its subsidiaries only, despite the fact that independent steel producers participated in the hearings and the arguments of the original case in 1919 and 1920.

Another matter before the Trade Commission attracted considerable attention—the charge made on behalf of domestic producers that British makers of ferromanganese and their American agents had been dumping that product in this market. There were protracted hearings. The final decision was that the charge of dumping had not been sustained.

The Federal Trade Commission has taken a position of antagonism to many iron and steel companies in its efforts to compel all such companies to submit to it regular detailed reports of their costs. The demands of the Trade Commission for data and for the filling out of forms entirely different from those used in company business, involving in some cases an expense of thousands of dollars a year, are being contested vigorously and the case is now before the Supreme Court of the District of Columbia.

Consolidation Tendencies.—The probability that a number of independent steel companies would be consolidated was before the trade during the year. The strain all producers were under in 1921 and the prospect that a condition of unprofitable operation would continue for some time have caused leaders in the industry to think seriously of various merger projects. Saving in overhead and the benefits of mass production through concentrating operations in a given line of product at a particular plant have been among the advantages considered. Just as the consolidations of the late eighteen-nineties and the early nineteen-hundreds came after the depression that began in 1893, so the present period of distress for iron and steel works is developing a tendency to concentration.

Seven companies are involved in the most important consolidation project now being worked on: Midvale Steel & Ordnance Co., Lackawanna Steel Co., Youngstown Sheet & Tube Co., Republic Iron & Steel Co., Inland Steel Co., Steel & Tube Co. of America, and Brier Hill Steel Co. Their combined steel-ingot capacity is about 20 per cent. of the country's total, while that of the Steel Corporation is 45 per cent.

A separate project involving the merger of the Youngstown Sheet & Tube Co., Inland Steel Co. and Steel & Tube Co. of America had been under negotiation before the seven-company merger was seriously taken up. More recently the three-company merger has seemed to have better prospects of consummation than the other. A number of smaller mergers are also talked of, and in the last 10 days of 1921 the American Rolling Mill Co. acquired the Ashland Iron & Mining Co., Ashland, Ky., with its two blast-furnaces, six open-hearth furnaces, sheet mills, and coal and timber lands.

Operating Deficits.—The year was disastrous for producers of iron and steel in all lines. A statement submitted at Chicago in December at the hearing on Lake Superior iron-ore rates before an examiner of the Interstate Commerce Commission made the following showing of deficits in the first three quarters of the year: Republic Iron & Steel Co., $2,177,472; Lackwanna Steel Co., $2,182,687, Midvale Steel & Ordnance Co., $3,933,731. The United States Steel Corporation showed net earnings of $32,286,722 in the first quarter, against $42,089,019 in the first quarter of 1920; $21,892,016 in the second quarter, against $43,155,705 in 1920, and $18,918,058 in the third quarter, against $48,051,540. The corporation paid its preferred and common dividends for all three quarters. After such payments it had a balance of $2,816,905 in the first quarter and deficits of $4,571,668 and $6,965,504 in the next two quarters. The more favorable showing for the Steel Corporation than for independent companies may be explained in part in the light of the $95,000,000 fund it set aside from surplus "to absorb any sudden and violent diminution in inventory valuations." Charges and allowances for depreciation have been considerably less than in times of good earnings.

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Pig Iron

The production of pig iron in the United States in 1921 was 16,688,126 gross tons of all kinds, which compares with 36,925,987 tons in 1920, 31,015,364 tons in 1919, and 39,434,797 tons in the record year of 1916. The production in the first half of 1921 was 9,530,981 tons, 2,373,836 tons more than in the second half. The production in the first half of 1920 was 658,765 tons less than in the second half.

MONTHLY PRODUCTION OF PIG IRON, LONG TONS

	1917.	1918.	1919.	1920	1921.
January	3,150,938	2,411,768	3,302,260	3,015,181	2,416,292
February	2,645,247	2,319,299	2,940,168	2,987,879	1,937,257
March	3,251,352	3,213,091	3,090,243	3,357,907	1,595,522
April	3,334,960	3,288,211	2,478,218	2,739,797	1,193,041
May	3,417,340	3,446,412	2,108,056	2,985,682	1,221,221
June	3,270,055	3,323,791	2,114,863	3,043,540	1,064,833
Total first half	19,069,892	18,002,572	16,033,808	18,138,986	9,428,166
July	3,342,438	3,420,988	2,428,541	3,067,043	864,555
August	3,247,947	3,389,585	2,743,388	3,147,402	954,193
September	3,133,954	3,418,270	2,487,965	3,129,323	985,529
October	3,303,038	3,486,941	1,863,558	3,292,597	1,246,676
November	3,205,794	3,354,074	2,392,350	2,934,908	1,415,481
December	2,882,918	3,433,617	2,633,268	2,703,855	1,649,086
Total second half	19,116,089	20,503,675	14,549,070	18,275,128	7,115,520
Grand total(a)	38,185,981	38,506,047	30,582,878	36,414,114	16,543,686

(a) These totals do not include charcoal pig iron and are from *The Iron Age*.

Pig-iron output in the United States since 1820 is given in the following table:

PIG-IRON PRODUCTION FOR 100 YEARS
(Long Tons)

1820	20,000	1861	653,164	1882	4,623,323	1903	18,009,252
1828	130,000	1862	703,270	1883	4,595,510	1904	16,497,033
1829	142,000	1863	846,075	1884	4,097,868	1905	22,992,380
1830	165,000	1864	1,014,282	1885	4,044,526	1906	25,307,191
1831	191,000	1865	831,770	1886	5,683,329	1907	25,781,361
1832	200,000	1866	1,205,663	1887	6,417,148	1908	15,936,018
1840	286,903	1867	1,305,023	1888	6,489,738	1909	25,795,471
1842	215,000	1868	1,431,250	1889	7,603,642	1910	27,303,567
1846	765,000	1869	1,711,287	1890	9,202,703	1911	23,649,547
1847	800,000	1870	1,665,179	1891	8,279,870	1912	29,726,937
1848	800,000	1871	1,706,793	1892	9,157,000	1913	30,966,301
1849	650,000	1872	2,548,713	1893	7,124,502	1914	23,332,244
1850	563,755	1873	2,560,963	1894	6,657,388	1915	29,916,213
1852	500,000	1874	2,401,262	1895	9,446,308	1916	39,434,797
1854	657,337	1875	2,023,733	1896	8,623,127	1917	38,621,216
1855	700,159	1876	1,868,961	1897	9,652,680	1918	39,051,991
1856	788,515	1877	2,066,594	1898	11,773,934	1919	31,015,364
1857	712,640	1878	2,301,215	1899	13,620,703	1920	36,925,987
1858	629,548	1879	2,741,853	1900	13,789,242	1921	16,688,126
1859	750,650	1880	3,835,191	1901	15,878,354		
1860	821,223	1881	4,144,254	1902	17,821,307		

Below is given the production by half-yearly periods for 1916 to 1921, in gross tons, as compiled by the American Iron and Steel Institute.

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All pig iron and ferro-alloys are included, whether made in blast-furnaces or in electric furnaces.

Periods.	1916.	1917.	1918.	1919.	1920.	1921.
First half	19,619,522	19,258,135	18,227,730	16,278,175	18,133,611	9,530,981
Second half	19,815,275	19,389,262	20,824,261	14,737,189	18,792,376	7,157,145
Total	39,434,797	38,647,397	39,051,991	31,015,364	36,925,987	16,688,126

Increases in production were made in all states except Massachusetts and Connecticut, as is shown in the following table of production by states.

PRODUCTION OF PIG IRON BY STATES
(In tons of 2240 lb.)

States.	1915.	1916.	1917.	1918.	1919.	1920.	1921.
Massachusetts and Connecticut	7,802	5,719	10,527	11,485	13,678	10,281	2,142
New York	2,104,780	2,352,535	2,417,529	2,877,118	2,070,288	2,601,134	968,660
New Jersey	12,790,668	16,506,824	15,539,728	15,198,271	12,296,585	13,983,134	6,252,766
Pennsylvania	251,548	501,452	422,212	373,817	244,002	523,733	147,189
Maryland	251,346	399,885	520,311	513,737	319,409	429,302	67,239
Virginia	2,049,453	2,762,885	2,953,705	2,587,852	2,130,092	2,392,962	1,207,408
Alabama	(b)291,040	(b)554,590	561,951	594,675	413,091	772,379	264,759
West Virginia	177,729	355,374	369,951	369,822	190,514	283,207	19,479
Kentucky	6,912,962	8,602,895	8,518,603	8,764,132	7,102,627	8,533,470	3,799,613
Tennessee	2,447,220	3,922,512	3,456,915	3,440,307	2,558,213	3,280,875	1,612,033
Ohio	a1,986,778	(a)2,221,708	2,657,503	3,703,599	2,715,659	2,939,521	(a)1,893,611
Illinois	372,966	811,325	738,541	750,366	605,619	711,405	226,863
Michigan	271,921	437,633	453,742	502,810	375,587	464,584	226,364
Wisconsin, Minn.							
W. of Miss. River							
Total	29,916,213	39,434,797	38,621,216	39,051,991	31,015,364	36,925,987	16,688,126

(a) Includes Indiana. (b) Includes Mississippi.

Production of pig iron from 1915 to 1921 according to fuel used is given below:

PIG-IRON PRODUCTION ACCORDING TO THE FUEL USED
(In tons of 2240 lb.)

Fuel Used.	1915.	1916.	1917.	1918.	1919.	1920.	1921.
Coke(a)	29,535,306	38,844,598	37,889,824	38,421,175	30,549,930	36,300,024	16,579,653
Anthracite & coke	84,753	217,788	381,048	283,592	138,337	302,567	13,743
Anthracite alone							
Charcoal	296,152	372,411	376,523	347,224	327,097	323,396	94,730
Charcoal & coke							
Total	29,916,213	39,434,797	38,647,397	39,051,991	31,015,364	36,925,987	16,688,126

(a) Under coke furnaces are included the very few which use raw bituminous coal. It may be assumed that 99 per cent. of this class of iron was made with coke. Also includes ferro-alloys made with electricity, electricity and coke, etc.

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Below is listed the production of pig iron according to character of product. Low-phosphorus pig iron, that is, running under 0.04 per cent. phosphorus, is included in Bessemer pig iron; the latter is iron containing from 0.04 to 0.10 per cent. phosphorus. The figures for the last 5 years include under basic iron a small quantity of charcoal iron of basic grade. Nearly all of the charcoal iron is classed as foundry iron; pig iron of high silicon content is included in the foundry group, while under "all other grades" are included white and mottled iron, direct castings, and miscellaneous ferro-alloys.

PRODUCTION OF PIG IRON BY GRADES

Years.	Basic.	Bessemer.	Foundry.	Malleable.	Forge.	All Other.	Total, Gross Tons.
1912	11,417,886	11,664,015	5,073,873	825,643	469,183	276,337	29,726,937
1913	12,536,693	11,590,113	5,220,343	993,736	324,407	300,860	30,966,152
1914	9,670,687	7,859,127	4,533,254	671,771	361,651	235,754	23,332,244
1915	13,093,214	10,523,306	4,864,348	829,921	316,214	289,210	29,916,213
1916	17,684,087	14,422,457	5,553,644	921,486	348,344	504,779	39,434,797
1917	17,671,662	13,714,732	5,328,258	1,015,579	345,579	545,278	38,621,216
1918	18,646,174	13,024,966	5,142,607	1,117,914	393,932	726,398	39,051,991
1919	14,494,131	9,975,934	4,916,758	1,009,049	271,286	348,206	31,015,364
1920	16,737,722	12,062,084[1]	5,957,782	1,310,951	318,048	539,400	36,925,987
1921	7,753,071	5,595,215	2,568,136	457,340	112,748	201,616	16,688,126

Of the 16,688,126 tons of pig iron made in 1921, 3,728,019 tons, or 22.3 per cent., was for sale, and 12,960,107 tons was for the maker's use. In 1920 the proportion for sale was 29 per cent.

The number of blast-furnaces in the United States at the close of each year since 1916 is given in the following table:

BLAST-FURNACES IN UNITED STATES

Fuel Used—Blast-furnaces.	1916.	1917.	1918.	1919.	1920.	1921.
Bituminous coal and coke	388	420	.....	.....	419	419
Anthracite, and anth. and coke	20					
Charcoal	40	35	.....	.....	.....	.....
Total	448	455	.....	428	419	419

New blast-furnaces completed in 1921 do not approach the remarkable record made in 1917. *The Iron Age*[1] gives a total of only 1, as compared with 6 in 1920, 2 in 1919, 8 in 1918, 14 in 1917, and 4 in 1916. The one furnace completed represents a capacity of about 180,000 gross tons of pig iron. For 1922 there are only 2 blast-furnaces under construction, which will probably be completed during the year, having an estimated

[1] Jan. 5, 1922.

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annual capacity of about 310,000 tons. The following table gives details of new blast-furnaces completed in 1921 and at present under construction:

Company.	Completed in 1921.	Under Construction or Projected.
Trumbull Cliffs Furnace Co., Warren, Ohio	1	..
E. W. Mudge & Co. (Claire No. 1), Sharpsville, Pa.	..	1
Hamilton Furnace Co., Hamilton, Ohio	..	1
Total	1	2

Several companies rebuilt or are rebuilding their furnaces or plan to do so, which will add materially to their capacity and efficiency. The new furnace of the Hamilton Furnace Co. and of E. W. Mudge & Co., while replacing old furnaces, are being erected on new foundations.

STEEL

The statistics of the output of steel in the United States for a number of years past are as follows:

PRODUCTION OF STEEL INGOTS AND CASTINGS FOR 14 YEARS
(In tons of 2240 lb.)

	Acid.								Basic.		Total.
	Bessemer.		Open-hearth.		Crucible, etc.*		Total.		Open-hearth.		
	Tons.	P.c.	Tons.	P.c.	Tons.	P.c.	Tons.	P.c.	Tons.	P.c.	Tons.
1908	6,116,755	43.7	696,304	4.9	69,763	0.5	6,882,822	49.4	7,140,425	50.9	14,023,247
1909	9,330,783	39.0	1,076,464	4.5	130,302	0.5	10,537,549	44.0	13,417,472	56.0	23,955,021
1910	9,412,772	36.1	1,212,180	4.6	177,638	0.7	10,802,590	41.4	15,292,329	58.6	26,094,919
1911	7,947,854	33.6	912,718	3.8	129,602	0.4	8,990,174	37.8	14,685,932	62.2	23,676,106
1912	10,327,901	33.4	1,139,221	3.6	142,679	0.4	11,609,801	37.2	19,641,502	62.8	31,251,303
1913	9,545,706	30.5	1,255,305	4.0	155,237	0.5	10,956,248	35.0	20,344,626	65.0	31,300,874
1914	6,220,846	26.5	903,555	3.8	117,500	0.5	7,241,901	30.8	16,271,129	69.2	23,513,030
1915	8,287,213	25.8	1,370,377	4.3	184,721	0.6	9,842,311	30.6	22,308,725	69.4	32,151,036
1916	11,059,039	25.8	1,798,769	4.2	298,610	0.7	13,156,418	30.7	29,616,658	69.3	42,773,680
1917	10,479,960	23.2	2,061,386	4.6	431,754	1.0	12,972,605	28.8	32,087,507	71.2	45,060,607
1918	9,376,236	21.1	1,982,820	4.5	626,805	1.4	11,985,861	27.0	32,476,571	73.0	44,462,432
1919	7,271,562	21.0	1,229,382	3.5	450,976	1.3	8,951,920	25.8	25,719,312	74.2	34,671,232
1920	8,883,087	21.1	1,296,172	3.1	577,952	1.4	10,757,211	25.6	31,375,723	74.4	42,132,934
1921	4,015,938	20.4	507,238	2.6	178,057	0.8	4,701,370	23.8	15,042,564	76.2	19,743,797

* Includes basic electric.

Included in the 15,042,564 tons of basic open-hearth steel ingots and castings produced in 1921 are 3,840,251 tons of duplex steel ingots and castings which were made from metal partly purified in Bessemer converters and finally purified in basic open-hearth steel furnaces, against 3,279,119 tons in 1920, a decrease of 2,438,868 tons, or 74.38 per cent. In 1919 the production of duplex steel was 2,819,785 tons and in 1918 it was 3,870,017 tons.

In 1920 duplex steel was produced by 9 works in 6 states, against

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9 works in 6 states in 1919, 10 works in 6 states in 1918 and 1917, and 9 works in 5 states in 1916. Data for 1921 have not been published.

Rails.—The total production of steel rails in the United States in 1921 was 2,178,818 gross tons, against 2,604,116 tons in 1920, a decrease of 16.2 per cent. Below is given the record of rail production for the period 1911 to 1921, according to process of manufacture:[1]

PRODUCTION OF ALL KINDS OF RAILS IN GROSS TONS

Years.	Rails.	Open-hearth Steel.	Bessemer Steel.	Re-rolled Steel.*	Electric Steel.	Iron.	Total.
1911		1,676,923	1,053,420	91,751	462	234	2,822,790
1912		2,105,144	1,099,926	119,390	3,455	.....	3,327,915
1913		2,527,710	817,591	155,043	2,436	.....	3,502,780
1914		1,525,851	323,897	95,169	178	.....	1,945,095
1915		1,775,168	326,952	102,083	.....	.....	2,204,203
1916		2,269,600	440,092	144,826	.....	.....	2,854,518
1917		2,292,197	533,325	118,639	.....	.....	2,944,161
1918		1,945,533	494,193	101,256	.....	.....	2,540,982
1919		1,893,250	214,121	96,422	50	.....	2,203,843
1920		2,334,222	142,899	126,698	297	.....	2,604,116
1921		2,027,215	55,559	96,039	5	.....	2,178,818

* Re-rolled from old steel rails and renewed rails which the manufacturers could not classify as Bessemer or open-hearth.

Girder and high T-rails for electric and street railways are included in the figures given above. For recent years the tonnage was as follows: 1916, 127,410; 1917, 91,674; 1918, 20,834; 1919, 112,712; 1920, 100,910; 1921, 89,162 gross tons.

The total production of rails as given above includes, in addition to new rails rolled during the year, rails re-rolled from defective rails and from old rails. The total of renewed or re-rolled rails so included is given in gross tons in the following table.

PRODUCTION OF RENEWED AND RE-ROLLED RAILS, 1914–1921

Years.	Re-rolled from New Seconds, New Defective Rails, etc.			Rolled from Old Rails.	Total Re-rolled.
	Open-hearth.	Bessemer.	Total.		
1914	13,538	13,234	26,772	95,169	121,941
1915	6,477	2,652	9,129	102,083	111,212
1916	1,711	2,149	3,860	144,826	148,686
1917	1,825	7,182	9,007	118,639	127,646
1918	13,296	19,462	32,758	101,256	134,014
1919	1,933	5,766	7,699	96,422	104,121
1920	19,493	1,979	21,472	126,698	148,170
1921	6,525	702	7,227	96,039	103,266

[1] *Bull.* 2 (1922), Amer. Iron and Steel Inst.

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WEIGHT OF ALL KINDS OF RAILS

Years—Gross Tons.	Under 45 Lb. per Yard.	45 Lb. and Less than 85.	85 Lb. and Less than 100.	100 Lb. and Over.	Total Gross Tons.
1912	248,672	1,118,592	1,960,651		3,327,915
1913	*270,405	†967,313	2,265,062		3,502,780
1914	*238,423	†309,865	868,104	528,703	1,945,095
1915	*254,102	†518,291	742,816	688,995	2,204,203
1916	*295,535	†566,791	1,225,341	766,851	2,854,518
1917	*308,258	†882,673	989,704	763,526	2,944,161
1918	*387,907	†615,165	888,141	592,462	2,533,675
1919	*263,803	†495,577	965,571	478,892	2,203,843
1920	*489,043	†433,333	952,622	729,118	2,604,116
1921	*211,568	†214,936	902,748	849,566	2,178,818

* Includes rails under 50 lb. † Includes 50 lb. and less than 85 lb.

Included above is the annual production of alloy-treated rails, shown separately in the following tables.

PRODUCTION OF ALLOY-TREATED STEEL RAILS

Years.	Total Production, Gross Tons.	Production by Alloys.		Production by Processes.	
		Titanium.	Other Alloys.	Open-hearth and Electric.	Bessemer.
1912	149,267	141,773	7,494	38,539	108,874
1913	59,519	47,655	11,864	40,393	25,952
1914	27,937	23,321	4,616	33,567	490
1915	24,970	21,191	3,779	27,447	603
1916	28,562	26,493	2,069	24,367	887
1917	16,535	15,273	1,262	27,675	*Nil.*
1918	3,111	2,891	220	3,111	*Nil.*
1919	6,476	6,207	269	6,476	*Nil.*
1920	12,909	11,652	1,257	12,909	*Nil.*
1921	6,276	2,804	3,472	6,276	*Nil.*

Rolled Iron and Steel.—In 1921, the production of all kinds of iron and steel rolled into finished forms (including blooms, billets, and axle blanks rolled for forging purposes and semi-finished products which were rolled for export in that year) shows a decrease of 17,573,857 tons, or 54.33 per cent., as compared with the output in 1920.

TOTAL PRODUCTION OF ALL KINDS OF FINISHED ROLLED IRON AND STEEL

Years.	Iron and Steel Rails.	Plates and Sheets.	Nail Plate.	Wire Rods.	Structural Shapes.	All Other Finished Rolled Products.	Total, Gross Tons.
1912	3,327,915	5,875,030	45,331	2,653,553	2,846,487	9,908,475	24,656,841
1913	3,502,780	5,751,037	37,503	2,464,807	3,004,972	10,030,144	24,791,243
1914	1,945,095	4,719,246	38,573	2,431,714	2,031,124	7,204,444	18,370,196
1915	2,204,203	6,077,694	31,929	3,095,907	2,437,003	10,546,188	24,392,924
1916	2,854,518	7,453,930	30,088	3,518,746	3,029,964	15,493,093	32,380,389
1917	2,944,161	8,267,616	22,864	3,137,138	3,110,000	15,585,921	33,067,700
1918	2,540,892	8,799,135	18,310	2,562,390	2,849,969	14,385,058	31,155,754
1919	2,203,843	7,372,814	12,832	2,538,476	2,614,086	10,359,543	25,101,544
1920	2,604,116	9,337,680	20,577	3,136,907	3,306,748	13,941,835	32,347,863
1921	2,178,818	4,260,574	14,573	1,564,330	1,272,624	5,483,087	14,774,006

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Rolled blooms and billets for forging purposes are included above, while semi-finished products rolled for export are included for 1912 and subsequent years.

PRODUCTION OF THE U. S. STEEL CORPORATION
Including Tennessee C., I., & Ry. Company

	1916.	1917.	1918.	1919.	1920.	1921.
Iron Ore Mined—	Tons.	Tons.	Tons.			
From Marquette Range	647,132	491,760	338,344	.....	.....	.....
From Menominee Range	996,983	1,120,382	1,172,319	.....	.....	.....
From Gogebic Range	2,369,460	2,197,554	1,916,220	.....	.....	.....
From Vermillion Range	1,314,002	1,039,807	808,994	.....	.....	.....
From Mesabi Range	24,928,039	23,806,268	21,574,526	.....	.....	.....
In Southern Region	3,099,553	3,125,998	2,522,536	.....	.....	.....
Total	33,355,169	31,781,769	28,332,939	28,893,123	27,021,009	16,422,682
Coke Manufactured	18,901,962	17,461,675	17,757,636	15,463,649	16,208,111	9,825,264
Coal Mined, not used in making coke	6,162,340	6,942,298	6,354,980	5,937,487	6,443,409	7,081,836
Limestone Quarried	7,023,474	6,494,917	5,141,365	5,835,289	5,981,022	4,607,486
Blast-furnace Products—						
Pig iron	17,412,049	15,460,638	15,700,561	13,481,738	14,352,617	8,547,199
Spiegel	31,486	192,290	240,393	155,766	180,029	131,063
Ferromanganese and ferrosilicon	164,102					
Total	17,607,637	15,652,928	15,940,954	13,637,504	14,532,646	8,678,262
Steel Ingot Production—						
Bessemer ingots	7,273,766	6,405,390	5,630,246	4,788,242	5,402,839	2,950,897
Open-hearth ingots	13,636,823	13,879,671	13,953,247	12,412,131	13,875,067	8,015,450
Total	20,910,589	20,285,061	19,583,493	17,200,373	19,277,960	10,996,347
Rolled and Other Finished Products for Sale—						
Steel rails	1,533,681	1,594,196	1,471,508	1,361,358	1,490,61	1,480,049
Blooms, Billets, Slabs, Tinplate Bars	1,881,526	1,692,348	1,489,737	975,020	1,023,762	409,767
Plates	1,332,262	1,473,625	2,171,362	1,578,360	1,759,263	723,355
Heavy Structural Shapes	1,029,682	1,004,537	1,079,601	855,118	1,040,619	439,762
Merchant Steel, Skelp, Hoops, Bands	2,715,277	2,650,970	2,159,279	2,270,711	2,846,686	1,125,961
Tubing and Pipe	1,338,892	1,234,129	1,190,594	1,192,582	1,429,691	984,285
Rods	278,197	267,071	209,350	161,053	254,968	88,252
Wire and Products of Wire	2,004,494	1,821,985	1,445,567	1,438,439	1,757,141	915,651
Sheets—Black, Galvanized and Tinplate	1,786,642	1,740,949	1,356,119	1,381,515	1,610,531	1,024,542
Finished Structural Work	557,953	550,744	503,380	351,704	416,469	272,621
Angle and Splice Bars and Joints	277,271	207,846	145,305	188,707	235,913	198,397
Spikes, Bolts, Nuts and Rivets	95,096	91,980	67,514	39,009	93,464	60,297
Axles	173,530	220,291	141,480	75,494	97,145	22,567
Sundry Iron and Steel Products	456,289	392,240	418,687	91,919	98,415	79,753
Total	15,460,792	14,942,911	13,849,483	11,997,935	14,228,502	7,860,334
Spelter	55,898	67,418	41,715	45,949	63,077	33,426
Copperas (Sulphate of Iron)	46,263	43,942	42,321	35,197	40,291	24,499
Universal Portland Cement (Bbl.)	10,425,600	10,917,000	7,287,000	9,112,000	11,960,000	12,499,000

Electric Steel

The electric-steel production in 1921 was 169,499 tons, a decrease of 66.2 per cent. from 1920, of which 53,162 tons was alloy-steel ingots and 10,084 tons alloy-steel castings.

The production of electric steel in the United States is as follows:

1909	13,762
1910	52,141
1911	29,105
1912	18,309
1913	30,180
1914	24,009
1915	69,412
1916	168,918
1917	304,543
1918	511,364
1919	384,452
1920	502,152
1921	169,499

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Electric Steel Furnaces.—Despite the acute depression prevailing in the steel industry, the expansion in the electric-steel industry in 1921, as measured by the number of new installations of various types of furnaces, was practically equal to that in 1920.[1] This is an unexpected development. No attempt has been made in this year's review to obtain data regarding other countries than the United States and Canada.

On Jan. 1, 1921, according to *The Iron Age's* annual review of the electric-steel industry, published in the issue of Jan. 6, 1921, the United States was credited with 356 furnaces of all types, with 43 in Canada; on Jan. 1, 1922, these totals have been increased to 388 in this country and 50 in Canada. This compares with only 19 such furnaces in the United States and 3 in Canada on July 1, 1913, or nine and one-half years ago. The total in the world on Jan. 1, 1921, was estimated at 961. From facts known and deductions that are possible, the estimated number of all types in the world as of Jan. 1, 1922, is easily 1000 and probably more.

The review which follows gives as complete data as was obtainable regarding every type of furnace. Concerning one prominent type no data were reported by the seller and, as indicated in the tables, one or two other selling companies could not see their way to supply information this year. In such cases, where reliable data could not be obtained from other sources, this information as of Jan. 1, 1921, was left standing. It is acknowledged that this results in incomplete data for the whole industry, but the general trend is indicated, despite the fact that some furnaces may be entirely out of commission.

Progress in the United States and Canada in 1921.—The net increase in the number of electric steel furnaces in the United States in 1921 has been 32 against 33 in 1920; 36 in 1919; 54 in 1918; 97 in 1917; and 63 in 1916. The total on Jan. 1, 1922, was 388, as compared with 356 on Jan. 1, 1921; with 323 on Jan. 1, 1920; 287 on Jan. 1, 1919; 233 on Jan. 1, 1918; and 136 on Jan. 1, 1917. The apparent net increase of 32 furnaces in 1921 is less than the actual, due either to the passing out of commission of some installations or to cancellations of contracts, some of which were not reported.

The expansion of the American electric-furnace industry may be appreciated when it is recalled that on July 1, 1913, there were only 19 furnaces using electricity. The expansion is therefore over 20 times.

In Canada the industry shows a net gain of 7 furnaces in 1921. The actual gain is larger, but the total increase is explained in part by the fact that a more complete report of the Volta and other installations was

[1] Edwin F. Cone, *Iron Age*, January, 1922.

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possible the past year than the previous one. Our record shows 50 furnaces in Canada on Jan. 1, 1922, as against 43 on Jan. 1, 1921; 19 on Jan. 1, 1917; and only 3 on July 1, 1913.

The net increase in the two countries has been 39 furnaces in 1921, or close to 10 per cent. This contrasts with 36 in 1920; with 33 in 1919; 31 in 1918; and 114 in 1917.

The table of Heroult furnaces this year has been secured to date and contains all of that type now in existence or contracted for as of Jan. 1, 1922. The total of this type on Jan. 1, this year, was 164 in the United States and 15 in Canada, a net gain of 5 in the United States and a net loss of 3 in Canada, accounted for by the changes at the plant of the Baldwins Canadian Steel Corporation, Ltd., Toronto. The net gain for the total of the two countries is therefore only 2 furnaces in 1921.

Among the new Heroult installations in the United States in 1921 were the following: One 6-ton furnace for ingots at Milton Mfg. Co., Milton, Pa.; one 1-ton for castings at Electric Engineering & Foundry Co., Tacony, Pa.; one 3-ton for castings at Lorain Steel Co., Johnstown, Pa.; and one 6-ton for ingots at Henry Disston & Sons, Philadelphia.

The American Bridge Co., New York, which sells the Heroult furnace, has brought out a modified design for a 7-ton furnace, the latest type.

Conspicuous among sales of new furnaces in 1921 is the Greene, with the reported sales of 5 furnaces as follows: Los Angeles Foundry Co., Los Angeles, Calif., one 1½-ton furnace for hard iron; Greene-Shaw Co., Berkeley, Calif., one ¼-ton for iron and steel; Eagle Brass Co., Seattle, Wash., two 250-lb. furnaces for Monel metal, iron, etc., and the Columbia Steel Co., Portland, Ore., one 1½-ton for steel.

The Greaves-Etchells furnace is credited with three new installations in 1921. Though not large in number these are significant as marking a contract for the largest electric furnace ever built and also as revealing plans for the largest electric-steel plant in the country, though definite announcement of this has not been made. The three new contracts referred to are two 10- to 15-ton furnaces and one 50- to 60-ton furnace for the Ford Motor Co. These supplement a 3-ton and a ½-ton of the same type in use for some time.

For the first time it is possible to publish a table of the installations of Volta furnaces. Previous to this only estimates have been available. Of these there are 2 in the United States and 11 in Canada, the furnace being distinctly a Canadian development.

The table of general furnaces includes some that were not published a

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year ago, mostly Canadian installations. These are based on Canadian Government records and account in part for the net increase in furnaces in Canada for 1921.

Data regarding the Moore and Pittsburgh furnaces were unobtainable from the sellers as in previous attempts to compile this review, but from data obtained from several sources it is possible to publish this year an estimate which is probably nearer the total than in past years. This estimate credits this type of furnace with 36 furnaces as contrasted with 24 a year ago.

An interesting fact is the sale of two Detroit rocking furnaces in 1921 for use in the iron industry. This is primarily a non-ferrous electric melting furnace. The new installations include one 1-ton furnace, 300 kva., at the Homestead Valve Mfg. Co., Homestead, Pa., for making gray-iron and semi-steel valve bodies, and one 1-ton furnace, 300 kva., for producing gray-iron and semi-steel castings.

One new installation of a Rennerfelt furnace is reported for 1921 at the plant of the Vaughan Motor Works, Portland, Ore. It is a ¼-ton furnace for steel castings.

No data were available from the sellers of the Von Schlegell or Booth furnaces. Statements were received that there had been no change in the Ludlum, Snyder or Grönwall-Dixon lists as published a year ago.

TABLE OF THE NUMBER OF ELECTRIC-STEEL FURNACES IN THE UNITED STATES AND CANADA

Type.	U. S. Jan. 1, 1922.	Canada, Jan. 1, 1922.	U. S. and Canada, Jan. 1, 1922	U. S. and Canada Jan. 1, 1921.	U. S and Canada, Jan. 1, 1920.	U. S and Canada, Jan. 1, 1919.
Heroult	164	15	179	177	170	163
Snyder and Von Schlegell(b).	52	2	54	54	49	48
Rennerfelt	18	0	18	17	18	13
Greaves-Etchells	26	2	28	25	18	11
Grönwall-Dixon	11	1	12	12	13	13
Ludlum	13	0	13	13	12	12
Girod	5	0	5	5	5	5
Booth (b)	14	0	14	14	12	11
Moore (a)	36	0	36	24	20	12
Induction	3	0	3	3	3	3
Webb	2	0	2	2	2	2
Stassano	1	0	1	1	1	1
Greene	23	0	23	18	11	8
Vom Baur	6	0	6	5	4	2
Wile	0	0	0	0	0	0
Detroit	3	0	3	1	1	0
Volta	2	11	13	8	.....	.....
Special (a)	9	19	28	20	24	27
Total	388	+ 50	= 438	399	363	330

(a) Estimated. (b) No report; data left same as a year ago.

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The table shows the number of furnaces by types in the United States and Canada as of Jan. 1, 1922, as well as the total of the two countries, compared with recent years.

Development in the World.—No attempt has been made this year to obtain data regarding the progress of the electric-steel industry in other countries than the United States and Canada. In the review covering the year 1920, data regarding the various types of furnaces in these countries were published, including a table which gave known and estimated figures for all countries and all types. According to this there were 562 electric furnaces of all types outside the United States and Canada. Of these 131 were Heroult, 85 were Rennerfelt, 65 were Greaves-Etchells, 7 were Snyder and 6 were Vom Baur, with other types estimated at 268. England led with 150, Germany following with 100 and France with 69 furnaces. Italy and Sweden were credited with 50 each, Norway and Austria (with Hungary) with 20 each, Japan with 11 and Spain and Luxemburg with 10 each.

It is known that these totals have been increased recently, so that it is safe to say that, allowing for additions and discontinuances and adding the present total of 438 in the United States and Canada, the world's total is easily 1000.

Of the total installations the United States is credited with 388, or practically 39 per cent. In the production of steel and iron in electric furnaces, this country easily leads all the rest, with a capacity probably equal to the total of the other countries combined.

Outstanding in the progress of 1921 is the introduction of the electric furnace into the manganese-steel and the gray-iron foundry industry—a movement sure to expand.

Iron-ore Resources of the World

A monograph published by the mining and metallurgical section of the East Europe Institute, Breslau, Germany, in the interest of German retention of Upper Silesia, gives some interesting figures on the developed iron-ore resources of the world. From these *The Iron Age* has compiled the subjoined table. Poland's interests have been pooled with those of France in this tabulation, as have those of Austria with Germany, and special emphasis is placed on the large share of control over iron ore now exercised by the French. The tabulation covers the German resources without Upper Silesia and gives to Poland Upper Silesia.

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EUROPEAN GROUPINGS OF IRON-ORE RESOURCES

	Iron Ore, Million Tons.		Percentage of the World.
France	2,300.0		
Lorraine	2,330.0		
Poland	17.8		
Upper Silesia	16.6		
France-Poland		5,664.4	25.2
Germany (without Upper Silesia)	1,262.0		
German Austria	213.2		
Germany-Austria		1,475.2	6.6
Great Britain		1,300.0	5.8
Scandinavian countries	1,525.0		
Spain	711.0		
Luxemburg	270.0		
Larger European neutrals		2,506.0	11.1
Russia		830.9	3.7
Other European countries		254.5	2.1
United States		4,250.0	19.0
Newfoundland		3,630.0	16.2
Other countries		2,780.0	12.4

The commanding position in the European steel trade conferred upon France as a result of the Treaty of Versailles is to be gathered from the following tables[1] showing the iron-ore reserves of the various European countries prior to the war and today:

1914.	Iron Ore. (Million	Metallic Iron. Tons)	Percentage of European Reserves.
France	3,300.0	1,140.0	27.4
Germany	3,607.7	1,270.0	29.9
Great Britain	1,300.0	455.0	10.8
Austria	251.0	90.0	2.1
Russia and Poland	848.7	382.1	6.9
Sweden and Norway	1,525.0	864.0	12.6
Spain	711.0	349.0	5.8
Luxemburg	270.0	90.0	2.2
Other countries	218.5	92.7	2.3

1921.	Iron Ore. (Million	Iron Contents. Tons)	Percentage of European Reserves.
France	5,630.0	1,895.0	46.7
Germany (without Upper Silesia)	1,262.0	511.0	10.5
Great Britain	1,300.0	455.0	10.8
German Austria	213.2	75.1	1.7
Russia	830.9	376.4	6.8
Poland (with Upper Silesia)	34.4	10.5	0.25
Scandinavian countries	1,525.0	864.0	12.6
Spain	711.0	349.0	5.8
Luxemburg	270.0	90.0	2.2
Other countries	255.4	102.0	2.65

The outstanding features of the alteration are three: First, Britain's unaltered position; second, France's overwhelming supremacy; and third, Germany's decline. France's reserves today are now four-and-a-half times those of Great Britain.

World's Production of Iron and Steel

The following tables give the latest available figures for the world's production of pig iron and steel, together with the figures for the last decade.

[1] *Metal Bull.*, Sept. 30, 1921.

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PIG-IRON PRODUCTION OF THE WORLD
(In metric tons)

Year.	Austria-Hungary.†	Belgium.	Canada.	France.	Germany.	Italy.	Japan.
1911.....	2,095,000	2,046,280	832,376	4,470,141	15,280,527	302,931	53,065
1912.....	2,312,689	2,301,290	920,636	5,939,194	17,852,571	379,987	56,341
1913.....	2,369,864	2,484,690	1,024,424	4,207,307	19,291,920	426,775	56,663
1914.....	2,020,000	1,454,400	710,481	2,690,546	14,389,547	385,114	74,055
1915.....	1,966,000	68,150	828,920	5,585,776	11,790,199	377,510	64,984
1916.....	2,418,322	127,825	1,060,787	1,488,691	13,314,238	467,005	77,283
1917.....	2,300,000*	7,990	1,063,084	1,734,967	13,142,247	471,180	.....
1918.....	1,200,000*	*Nil.*	1,084,642	1,306,494	11,754,542	313,576	.....
1919.....	600,000*	250,570	832,619	2,412,149	5,654,000*	239,710	.....
1920.....	800,000*	1,116,400	989,137	3,468,000	5,550,000*	88,072	377,616*
1921.....	.....	861,600	603,923	3,308,400	.....	50,400	.....

Year.	Russia.	Spain.	Sweden.	United Kingdom.	United States.	All Other Countries.	Total.
1911.....	3,521,000	408,667	633,800	9,718,638	34,027,940	485,000	73,831,693
1912.....	4,197,638	403,243	701,900	8,751,464	30,202,568	485,000	73,443,043
1913.....	4,548,376	424,773	735,000	10,481,917	31,482,406	495,000	79,133,124
1914.....	4,261,008	425,000	635,100	9,005,898	23,721,115	420,000	62,536,718
1915.....	3,696,560	439,835	767,600	8,793,659	30,414,817	415,000	64,367,234
1916.....	3,737,593	497,726	737,300	9,193,656	40,092,043	425,000	73,595,778
1917.....	1,700,000	357,699	821,200	9,572,190	39,243,018	450,000	70,863,575
1918.....	213,000	386,550	674,900	9,184,974	39,680,728	600,000	66,399,406
1919.....	115,000	294,167	497,400	7,517,108	31,514,711	700,000	50,627,434
1920.....	98,000	251,000	470,550	8,136,827	37,520,495	1,000,000	59,870,552
1921.....	115,000	.....	312,973	2,653,240	16,956,805	.....	.....

* Estimated. † Includes Czecho-Slovakia.

STEEL PRODUCTION OF THE WORLD
(In metric tons)

Year.	Austria-Hungary.†	Belgium.	Canada.	France.	Germany.	Italy.	Japan.
1911.....	2,363,008	2,192,630	800,504	3,680,613	15,019,333	736,000	10,222
1912.....	2,785,105	2,515,040	868,811	4,078,352	17,301,998	801,951	12,451
1913.....	2,682,619	2,466,630	1,060,503	4,686,886	18,958,819	846,085	13,728
1914.....	2,190,759	1,396,300	751,738	2,655,854	15,619,719	796,152	15,386
1915.....	2,686,226	98,820	926,157	1,087,700	13,237,646	1,009,240	16,766
1916.....	3,336,607	99,371	1,295,707	1,951,892	16,182,520	1,269,486	23,861
1917.....	2,927,789	9,530	1,583,786	2,231,651	16,587,360	1,331,641	.....
1918.....	1,763,745	10,540	1,699,886	1,807,931	13,756,813	992,523	.....
1919.....	800,000	333,660	934,726	2,186,260	6,877,398	731,823	.....
1920.....	1,098,755	1,253,110	1,126,753	2,961,508	7,710,000	773,761	1,031,550*
1921.....	1,116,313	780,000	678,230	3,010,800	.....	683,200	.....

Year.	Russia.	Spain.	Sweden.	United Kingdom.	United States.	All Other Countries.	Total.
1911.....	3,870,000	322,981	456,500	6,565,645	24,054,918	315,000	60,387,354
1912.....	4,498,000	317,880	508,300	6,904,546	31,751,324	325,000	72,668,758
1913.....	4,827,000	365,118	582,700	7,787,264	31,822,555	325,000	76,157,262
1914.....	4,732,000	382,044	500,600	7,918,243	23,904,914	300,000	61,163,709
1915.....	4,900,000	387,314	588,800	8,687,670	32,686,887	300,000	66,613,226
1916.....	4,696,000	322,931	717,600	9,344,520	43,462,336	320,000	83,026,332
1917.....	3,080,000	470,241	681,700	9,909,338	45,786,083	350,000	84,974,119
1918.....	410,000	303,206	524,800	10,434,059	45,178,307	500,000	77,381,810
1919.....	197,000	241,189	491,600	8,021,093	35,231,439	600,000	56,646,188
1920.....	164,000	.....	426,600	9,202,614	42,811,274	800,000	.....
1921.....	164,000	.....	.....	3,783,565	20,061,672	.....	.....

* Estimated. † Includes Czecho-Slovakia.

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American Steel and World Supply.[1]—A new low record for recent years in iron and steel output was made in 1921 in the sum total of the five leading countries. All were caught in the reaction from the false prosperity of 1919 and 1920. Germany and France were able to come close to their production of the preceding year. But for the world-wide depression, both probably would have shown a measurable gain. More reliable comparisons are possible than at this time last year, data as to Belgium and Germany not being available then. The 1919 and 1920 figures for Germany are based on information recently secured by the Berlin correspondent of *The Iron Age*, the first that has been made public there since October, 1919, when the printing of monthly production figures was stopped. For the United States and Great Britain the figures given below are close estimates for 1921 and official for other years, while those for France are based on nine months' statistics for last year and those for Belgium on 10 months' returns. For other years official data are given, corrected to date. Comparisons are made with 1920, 1919 and 1913:

OUTPUT OF PIG IRON AND STEEL (INCLUDING CASTINGS) IN FIVE COUNTRIES, GROSS TONS

Pig Iron.	1913.	1919.	1920.	1921. (a)
United States	30,972,000	31,015,300	36,925,900	16,750,000
Great Britain	10,260,000	7,398,000	8,007,900	2,611,400
Germany	16,765,000	5,654,000	5,550,000	5,750,000
France	5,124,000	2,376,000	3,380,400	3,294,000(b)
Belgium	2,445,600	247,200	1,112,000	875,600(b)
Total	65,566,600	46,690,500	54,976,200	29,281,000
Steel.				
United States	31,300,800	34,671,200	42,132,900	20,250,000
Great Britain	7,668,000	7,894,000	9,056,800	3,624,800
Germany	17,340,000	6,732,000	7,710,000	7,750,000
France	4,620,000	2,148,000	3,002,400	2,913,600(b)
Belgium	2,427,600	328,800	1,215,600	804,000(b)
Total	63,356,400	51,774,000	63,117,700	35,342,400

(a) Partly estimated. (b) For France based on 9 months' and for Belgium on 10 months' output.

The countries named probably produced about 90 per cent. of the world's steel in 1921. In 1920 the United States was credited with about 67 per cent. of the total production of both pig iron and steel. Last year the American percentage fell to about 57, a proportion by no means small in the light of a shrinkage of over 50 per cent. from the domestic output of 1920. Comparisons as to Great Britain must be made in the light of the coal strike which for three months seriously crippled that country's steel industry. Belgium in 1921 by no means kept up the rate of recovery indicated in 1920.

[1] *Iron Age*, Jan. 26, 1922.

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Total pig-iron output in 1921 was only 53 per cent. of that for 1920 and 45 per cent. of the 1913 total, while steel production in 1921 was only 56 per cent. of that for 1920 as well as of that for 1913. Between the pig-iron output and that of steel in the five countries last year the difference is about 6,000,000 tons, steel being over 20 per cent. greater. In 1920 the margin of over 8,000,000 tons was less than 15 per cent. In 1913, the pig-iron total at 65,500,000 tons was more than 2,000,000 tons greater than that of steel. The present-day preponderance of steel indicates the growth of the basic open-hearth steel industry with its large use of scrap and corresponding conservation of the world's iron-ore supply.

World Movement in Steel.[1]—Some striking changes are shown by an analysis of the iron and steel export statistics of the leading producing nations for 1921, which recently have been made complete. The figures for last year, compared with those for 1913 and 1920, are as follows in thousands of gross tons:

	1913.	1920.	1921.
United Kingdom	4,969	3,251	1,700
United States	2,892	4,706	2,180
France	578	895	1,525
Belgium	1,546	892	904
Germany	*6,203	1,723	†1,607
Total	16,188	11,467	7,916

*Luxemburg included. †Eight months, May to December.

The first fact that stands out is that in 1921 the total movement of 7,916,000 tons was about 70 per cent. of the exports in 1920, despite the world-wide depression. Compared with the iron and steel production in the same countries the difference is marked, because the 1921 pig-iron and steel output was only 53 per cent. and the steel output 56 per cent. of the 1920 figures. The conclusion is that a liquidation in stocks took place last year which was world-wide.

A second striking feature of these data is the pronounced rôle of France. Not only did that country exceed in 1921 its sales in 1920, but they easily surpassed the pre-war record in 1913 by nearly threefold. France is also the only country whose exports last year not only suffered no diminution as the year progressed, but also exceeded the pre-war record. With the acquisition of German capacity, France has been compelled to find new outlets in foreign trade.

One important development is not shown in the above table, and that is that at the close of the year Germany was leading all other countries in iron and steel exports, with Great Britain, France, the United States and Belgium following in the order named—a marked reversal of the position obtaining early in the year.

[1] *Iron Age*, Mar. 23, 1922.

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The volume of international trade in steel last year was less than 49 per cent. of what it was in the year before the war, and it is likely to be some years before these countries will equal or exceed combined exports of over 16,000,000 tons. Even in the boom of 1920, the total was far from reaching 1913 proportions. When world demand again approaches the pre-war scale the old alignment need not be expected, but whether the United States can improve on third position will depend on the right settlement of some questions of national policy in which the outcome is none too clear at this writing.

Iron and Steel in Foreign Countries

Algeria.—The shipments of iron ores from Algiers aggregated 684,964 metric tons in 1921, as against 1,114,438 tons in 1920, 758,199 tons in 1919, 782,047 tons in 1918, and 1,065,512 tons in 1917. Most of the ore is shipped to England.

Australia.—During the financial year ended May 30, 1921, the Broken Hill Proprietary Co.'s steel works at Newcastle, New South Wales, produced 227,533 long tons of pig iron and 209,458 tons of steel ingots, as compared with 171,139 tons of pig iron and 166,772 tons of steel ingots for the preceding year.[1] Wages were increased 8s. 4d. per week per man during the period, representing an increase of about 10 per cent., or upward of £500 a day, to the wages bill.

New impetus to the steel industry of the Commonwealth has been given by the formation of Hadfields (Australia) Limited, with a capital of £500,000. This company has taken over the works of the Australian Electric Steel Co. at Alexandria near Sydney, as well as works being erected near Perth, Western Australia. Hadfields Limited, the well-known Sheffield firm of steel makers, are interested in the Australian company, and Robert A. Hadfield is a director. The new company will, therefore, have the benefit of the Sheffield firm's long experience, and in addition to supplying local requirements will be in a favorable position to export to the East.

According to official data for the Commonwealth the record as to pig iron stands as follows, in long tons:

	1920.	1921.
Pig iron produced	605,626	352,365
Pig iron exported	.....	2,765
Pig iron imported	.....	1,423
Apparent home consumption	.....	349,600

An illuminating paper on the "Steel Industry of Australia," by David Baker, was delivered before the American Iron and Steel Institute, May 26, 1922. It is published in the Institute's Year Book.

[1] *Comm. Rept.*, Jan. 16, 1922.

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Another important article on Australian iron and steel was published in *The Iron Age*, Mar. 9, 1922, entitled "Progress of Steel Making in Australia," by Randolph Bedford, member of the Parliament of Queensland.

Austria.[1]—The iron ore mined in Austria, chiefly for the production of steel but partly for making cast iron, is of superior quality. That of the Erzberg Mountain, the largest deposit, has a content of only 0.02 to 0.04 per cent. phosphorus and belongs mainly to the Alpine Montangesellschaft, which mines and produces 98 per cent. of the iron ore and pig iron of Austria. Thanks to coke deliveries from the Ruhr district, production of pig iron and steel in 1921 was almost doubled as compared with the preceding year.

The output of the mines and works of the Alpine Montangesellschaft in metric tons was: Iron ore—1,953,398 tons in 1913, 428,519 in 1920, 301,947 in the first half of 1921, and 377,590 in the last half of 1921; pig iron—586,623 tons in 1913, 98,049 in 1920, 80,097 in the first half of 1921, and 134,225 in the last half of 1921. Only 2 out of 8 blast-furnaces owned by this company were active throughout 1921. The Alpine Montan worked at 24.65 per cent. of capacity in 1920, 31.96 per cent. of capacity during the first half of 1921, and 40.78 per cent. of capacity during the second half of 1921, being supplied with only 19.62 per cent. of its fuel requirements in 1920, 23.81 per cent. during the first half of 1921, and 63.04 during the second half of 1921.

Iron and steel foundries suffered from the depreciation of the Austrian crown last year, as they had to procure crude iron, coke, and coal from abroad. Scarcity of old iron was felt, and there was a lack of molders and casters. Another impediment in the fine-steel industry was the continuous rise in the cost of raw material and wages. Steel production, in metric tons, by the Alpine Montan was 419,627 tons of ingots in 1913, 125,779 tons in 1920, 65,159 tons during the first half of 1921, and 133,492 tons during the second half of 1921. Output of blooms and billets in 1913 was 13,529 tons. There were 9 Martin furnaces in use during the second half of 1921, as against 8 during the first six months of the year and 12 in 1913.

Finished products manufactured by the Alpine Montan were made of Martin steel, output of which was 417,680 metric tons in 1913, 123,985 in 1920, 64,612 in the first half of 1921, and 108,130 in the second half of 1921. The tonnage of the finished iron and steel was 267,746 tons in 1913, 94,734 in 1920, 50,484 in the first half of 1921, and 91,015 in the second half of 1921.

Belgium.—The last quarter[2] of 1921 in practically all lines of Belgian

[1] *Comm. Rept.*, May 22, 1922.

[2] *Comm. Rept.*, Mar. 20, 1922.

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iron and steel marked a continuation of the slow general improvement which first appeared in August and September. Between September and the end of December pig-iron production increased 83 per cent., while the raw-steel output practically doubled; the situation in rough castings is less favorable, with production figures stationary since July, 1921, in the neighborhood of 3300 tons monthly. Owing to some uncertainty felt as to the permanence of the revival, most plants have been slow to relight blast-furnaces, with the result that only 14 were in operation at the end of the year—5 in Hainaut (Charleroi), 4 about Liége, and 5 scattering.

Despite this improvement pig-iron production in December was only 36 per cent. of the 1913 monthly average and slightly under 80 per cent. of the 1920 average. The maximum number of blast-furnaces fired during 1921 was 26 in January, producing 112,330 tons of pig iron. At the close of the year the output of raw steel amounted to 30 per cent. of the monthly mean of 1913, and that of rough castings to 65 per cent.

According to the latest data the following are the revised figures as to the output of the Belgian iron and steel industry.[1]

	1913.	1916.	1917.	1918.	1919.	1920.
Number of blast-furnace plants at work	19	4	1	*Nil.*	8	14
Number of furnaces in blast	54	6	1	*Nil.*	13	18
Number of days in blast	340	222	110	*Nil.*	..	..
Number of steel plants at work	29	19	31	32	19	26
Number of iron- and steel-working plants	38	29	39	40	26	35

	1913.	1918.	1919.	1920.
Iron ore	150,450	500	4,820	17,260
Foundry iron	93,830	.....	43,670	60,310
Forge iron	66,370	.....	*Nil.*	980
Steel-making (Bessemer)	32,260	.....	22,930	44,560
Steel-making (open-hearth)	2,291,290	.....	183,970	1,005,550
Special pig iron	840	.....	*Nil.*	*Nil.*
Total pig iron	2,484,690	*Nil.*	250,570	1,116,400
Steel:				
Direct castings	61,850	260	333,560	60,720
Bessemer steel	2,192,180	*Nil.*		973,250
Open-hearth steel	212,600	10,280		219,140
Blooms and billets	1,524,990	250	214,340	747,430
Rolled steel	1,409,460	3,380		
Finished iron	304,350	51,060	58,895	209,000
Finished steel	448,449	13,600	127,820	1,131,730

Iron and steel exports from Belgium during 1921 amounted to 995,835 metric tons, a gain of 72,773 tons over the 923,062 tons exported in 1920. On the other hand, a decrease is noted in the imports of iron and steel, which totaled only 723,127 tons in 1921, against 1,050,226 tons in 1920.[2] Details of the exportation and importation in 1913, 1920, and 1921, as given in the monthly statistics issued by the Belgian Ministry of Finance, are furnished in the following tables:

[1] *Annales des Mines de Belgique.*
[2] *Comm. Rept.* Apr. 24, 1922.

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BELGIAN EXPORTS AND IMPORTS OF IRON AND STEEL
(In metric tons)

Products.	Exports.			Imports.		
	1913.	1920.	1921.	1913.	1920.	1921.
Scrap iron and steel	152,789	10,557	69,972	122,182	225,652	195,683
Pig iron	16,747	50,163	178,438	579,274	336,777	143,376
Slabs and blooms	43,291	7,542	3,707	54,390	171,922	150,378
Billets and sheet bars	110,327	20,569	19,871	20,962	103,906	71,496
Cast iron, manufactured	26,722	18,268	20,868	10,186	4,577	4,601
Forged or rolled iron and steel in bars or sheets:						
Beams	95,544	52,381	30,756	1,517	15,745	16,094
Rails	164,135	51,367	93,574	4,438	15,385	7,194
Sheets	196,204	138,489	98,306	18,669	34,042	10,668
Other	649,545	417,772	361,285	40,932	52,531	59,076
Wire rods	34,536	43,283	19,673	6,266	7,744	9,975
Nails (including wire nails)	15,566	21,937	19,845	923	669	554

A comparison of 1913 and 1921 shows that imports have practically regained their pre-war status, and that exports are now nearly 60 per cent. of the 1913 total. This is but one instance of the remarkable recovery made by this industry after the destruction wrought upon it during the World War.

Brazil.—The Brazilian iron-ore deposits are at present attracting great attention.[1] Some time ago one of the largest Luxemburg corporations (Arbed) acquired extensive deposits of ore in Brazil, and several other important concerns are also said to have been granted considerable concessions recently. Up to the outbreak of the war the Brazilian Government objected to the exportation of iron ores. Since the close of the war, however, the attitude of the Government has undergone considerable change, so that besides German and Luxemburg concerns, American, English, French, and Belgian corporations have also acquired concessions. A great drawback to the exportation of Brazilian iron ores is the lack of proper railway connections. The only railway line, the Central of Brazil, is not able to handle properly even the regular traffic, so that the transport of the manganese ores (in 1917 equaling 600,000 tons) was much hampered for a time. The Leopoldina Railway also intends extending its system into the interior of the State of Minas Geraes. A third possible line for the transport of the ores is the Victoria Minas (Diamantina) Railway, the shares of which are almost entirely in the hands of the English Itabira Iron-Ore Co.

An article on "The Brazilian Iron and Steel Industry," by Commercial Attaché W. L. Schurz, appeared in *Commerce Reports* for Mar. 27, 1922; it discusses ore deposits, export taxes, and research work. A later article, written under date of May 6, gives particulars of the construction

[1] *Eng. Min. Jour.*, Nov. 5, 1921.

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of a plant by the Companhia Electro Metallurgica Brazileira, in which Swedish electric pig-iron furnaces will be employed.

After various negotiations regarding the erection of the plant in May, 1920, the Metallurgica signed a contract with Corning & Co., Albany, N. Y., for the building, furnaces, and all machinery with the exception of the electrical equipment. In August of the same year, the Metallurgica ordered the necessary electrical equipment from the General Electric Co., and the following May broke ground for the plant.

The pig-iron furnace-building is a three-story structure, about 25 meters high. The ore, limestone and charcoal, after being mixed in proper proportions, are charged in the furnaces on the third floor. The furnaces are two in number, of the Electrometall shaft type, commonly used in Sweden, each one supplied by a transformer bank of 4650 kva. capacity, and capable of a normal output of 30 tons of pig iron per day. The furnaces are continuous in operation, having an annual load factor of 80 per cent. The Metallurgica has purchased the exclusive rights to construct and operate in Brazil this type of furnace, for a period of 10 years. The furnaces were built in the United States from the Swedish drawings. The liquid pig iron will be handled by one of two cranes serving the main building, and poured into one of the two six-ton Bessemer converters, to be blown to mild steel. The blowing engine is driven by a 675-hp. synchronous motor.

The steel will then be poured into the ingot molds or poured into a 6-ton electric steel furnace for further refining, which furnace will also melt down scrap iron, of which a considerable stock is already on hand.

The reheating furnaces for the ingots are to be fired by the iron-furnace gas, and have auxiliary oil burners. The roll trains are driven by two 500-hp. induction motors through reduction gears. The plan is to roll the simplest and easiest sections for which there is the greatest demand in that part of the country. The converters, electric steel furnace, reheating furnace, rolling mills and machine shop are in one building, 23 by 128 meters. Other buildings, such as offices, warehouses, charcoal storage house, etc., are under construction.

For a charcoal supply the Companhia Metallurgica has purchased 6000 acres of woods near Bertaozinho, and has erected 100 beehive ovens, the intention being in the near future to plant eucalyptus at a convenient site, and install a by-product plant.

The ore and limestone will come from the company's property near Sao Sebastiao de Paraiso, and will be transported by the Sao Paulo-Minao Railroad, on which the company has taken an option. Water for the plant will be obtained from the 16-in. aqueduct from the Rio Pardo. Power will be supplied by three generating stations of the Empreza

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Forca e Luz de Ribierao Preto (Light & Power Co. of Ribeirao Preto) which installed all electrical equipment. Corning & Co. sent out a staff of engineers to erect the plant and supervise the operations during the first few months.

The subject of electric steel in Brazil is treated in detail by N. A. V. Paulsson, consulting engineer for Corning & Co., who gives further details of this plant.[1]

Canada.—The pig-iron and steel output of Canada in 1921 was as follows, according to data issued by the Dominion Bureau of Statistics:

Pig Iron:		Gross Tons.
Basic		461,578
Foundry		97,304
Malleable		35,084
Castings		388
Total		594,354
Ferro-alloys		22,493
Steel Ingots and Castings:	**Ingots.**	**Castings.**
Open-hearth, basic	641,882	6,531
Open-hearth, acid	239	256
Bessemer	94	1,638
Electric	2,860	13,984
Total	645,075	22,409

The 1920 production of pig iron was 974,000 tons, and that of steel ingots and castings 1,109,000 tons.

Of the 1921 pig-iron output 610 tons was made in electric furnaces, and out of a total of 20 furnaces, 18 were idle at the end of December.

Following is the preliminary report for 1921 issued by the Dominion Bureau of Statistics:

The shipments of iron ore from Canadian mines, which in 1920 were the lowest on record for 20 years, again decreased by more than 50 per cent. The total quantity mined was 42,938 short tons, and shipments amounted to 59,408 tons. The only producing mine in Ontario was the Magpie, operated by the Algoma Steel Corporation, which accounted for 42,198 tons of the total mined. Other producers were the Wallbridge and Moose Mountain, which together shipped a hundred tons of briquets and ore. In British Columbia, some 900 tons, principally magnetite, was shipped from Texada Island and Mons to Seattle, Washington.

In Nova Scotia, the Dominion Iron and Steel Corporation and the Nova Scotia Steel and Coal Co. as usual brought in Wabana ores from Newfoundland.

In former years small shipments of titaniferous ore were made from Baie St. Paul in Quebec, but during 1921 no ore was mined and none was shipped from this locality.

Imports of iron ores during the year amounted to 661,168 tons valued at $2,109,094. Exports in the same period totaled only 4261 tons valued at $13,373.

The average monthly output of pig iron in Canada during the 12 months ending December was 50,000 tons or less than the average monthly record for any year since 1908. Throughout the entire period, during which a total of 595,000 long tons of pig iron was made, the market was decidedly quiet and the suspension of interest in iron was general. In the United States as in Canada the final weeks of 1921

[1] *Chem. Met. Eng.*, Dec. 7, 1921.

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were characterized by a quiet market and declining production. In spite of this there was evidence at the close of the year that there would be an early resumption of activities in the iron trade and the opinion was generally expressed that the first month of the new year would see the beginning of an upward movement in production.

The average monthly production during the year of steel ingots and castings was 56,000 tons as compared with 92,000 tons during the preceding year. The whole basic and acid open-hearth production of steel ingots was made by the operators for the use of their own mills. Of the Bessemer ingots produced 37 tons was used directly and the balance was produced for sale. A total of 2200 tons of electric-steel ingots was used by the plants reporting and 660 tons was made for sale.

Of the whole amount of steel castings 18,495 tons was made for sale and 3914 tons used by the firms reporting. An analysis of the 18,495 tons of direct steel castings made for sale shows 5081 tons was made by the basic open-hearth process, 252 tons in acid open-hearth furnaces, 1401 tons by the Bessemer process and 11,761 tons from electric furnaces.

China.—The most significant event[1] in Chinese mining during the year 1921 was the shutting down of the iron mines and blast-furnaces at Penhsihu, in Manchuria, according to information furnished the Bureau of Foreign and Domestic Commerce by Thomas T. Read, chief of the Information Service, U. S. Bureau of Mines. It is stated that a new blast-furnace plant was built during the year for the Lungyen company, a short distance west of the city of Peking. This was designed by an American firm and erected under its direction by a contracting firm in Shanghai. A record in speed of erection was made on this plant, which was described in some detail in *The Iron Age* of Dec. 8, 1921. The ore supply for this plant is to come from Lungkai and Yentungshan, near Hsuanhuafu, on the railway from Peking to Kalgan. The ore deposit is very large and is an interesting one, as it is oölitic, similar to the Clinton ores of this country, except that it has a silicious instead of a calcareous cement. The ore will have to be hauled over the Nankou pass to the blast-furnace and coal for coking purposes must be brought from either Liuhoku or Kailan.

The Kailan Mining Administration, which is a joint Chinese-British coal-mining company, and the largest producer in China, with an annual output of over 4,000,000 tons of coal, desires return cargo for its coal boats to the south coast of China, and has accordingly arranged to secure iron ore in the Yangtze Valley and bring it to Chinwangtao, the seaport of the local mine. Thus it is planning to go into the iron-smelting business. It is reported that the blast-furnace there will be in operation in 1922.

The production[2] of iron ore in 1920 is believed to have been slightly in excess of that mined in 1916, when the output was estimated at 1,338,520 long tons, of which 1,060,000 tons was smelted in China and the

[1] *Comm. Rept.*, Feb. 13, 1922.
[2] *Ironmonger* (London), Jan. 7, 1922.

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balance exported, mainly to Japan. The following table shows the principal ironworks already working or to be erected in the near future:

Name.	Capacity, Tons.	Condition.
Hunyang	150,000	In operation.
Tayeh	240,000	End of 1921.
Penchichu	80,000	In operation.
Anshanchan	100,000	Partly in operation.
Lungyen	80,000	End of 1921.
Yangtse Engineering	20,000	In operation.
Kungch'angling	30,000	Probably in 1922.
Chinwangtao	80,000	

Cuba.—Shipments of iron ore from Cuba to the United States in recent years were as follows, in gross tons:

Year.	Total.	South Coast.	North Coast.
1921	123,222	.....	.....
1920	889,852	.....	.....
1919	321,753	.....	.....
1918	632,442	(a)404,000	(a)228,000
1917	546,069	.....	.....
1916	716,571	.....	.....
1915	831,618	(a)520,000	(a)310,000
1914	815,017	(a)580,000	(a)270,000
1913	1,635,622	(a)1,090,718	(a)491,613
1912	1,397,797	951,621	446,176
1911	1,163,614	775,922	387,792
1910	1,462,498	1,154,798	307,700
1909	936,132	936,132	.....

(a) Estimated.

Czecho-Slovakia.[1]—Czecho-Slovakia in 1921 made 917,662 metric tons of steel of various kinds—75,742 tons of Bessemer and Thomas steel, 820,995 tons of Martin steel, 3772 tons of puddled steel, and 17,153 tons of electric steel. Compared with the 1920 production, the 1921 output declined by 55,314 tons, or 5.69 per cent. The reasons for this decrease are the high cost of production (due largely to costly coke and high freight-rates) and the general industrial depression that made its appearance toward the end of the year, causing a limitation and, in some cases, a complete cessation of production. The production of steel is still below the pre-war level, as shown by the following figures of steel output:

	Metric Tons.
1913	1,257,031
1917	1,601,079
1918	1,019,032
1919	786,022
1920	972,976
1921	917,662

France.—The iron and steel output, so far as obtainable in detail, is given in the following tables:

PIG-IRON PRODUCTION IN FRANCE
(In metric tons)

	1914.	1915.	1916.	1917.	1918.	1919.	1920.	1921.
Foundry	532,250	173,487	378,782	340,588	422,699	.....	797,939	.....
Forge	268,500	269,157	391,346	405,796	387,878	.....	275,153	.....
Bessemer	119,666	22,162	68,879	33,817	28,484	.....	76,289	.....
Basic	1,703,566	76,607	561,748	613,533	333,350	.....	2,050,129	.....
Special irons and alloys	66,564	44,363	87,936	141,233	134,083	.....	117,861	.....
Total	2,690,546	585,776	1,488,691	1,734,967	1,306,494	2,412,149	3,317,371	3,416,953

[1] *Comm. Rept.*, June 5, 1922.

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STEEL PRODUCTION IN FRANCE
(Metric tons)

	Bessemer.		Open-hearth.	Crucible and Electric.	Total.
	Acid.	Basic.			
1912	73,917	2,664,610	1,320,462	37,363	4,078,352
1913	252,704	2,806,475	1,582,478	43,209	4,686,866
1914	74,767	1,505,225	1,040,079	35,783	2,655,854
1915	29,827	59,459	944,836	53,578	1,087,700
1916	69,794	513,529	1,290,833	77,736(a)	1,951,892
1917	63,630	574,150	1,498,353	94,518(a)	2,231,651
1918	79,596	315,041	1,312,625	100,669(a)	1,807,931
1919	48,682	1,012,916	1,070,166	59,496(a)	2,186,260
1920	51,063	1,648,294	1,186,908	75,243(a)	2,961,508
1921	45,094	1,779,860	1,243,216	34,000	3,102,170

(a) Electric, 44,429 tons in 1916; 54,031 tons in 1917; 58,222 tons in 1918; 42,559 in 1919; 56,305 in 1920; and 24,487 in 1921.

Of the 1921 pig-iron total, 55,568 tons was made by the electric-furnace process. Phosphorus-bearing iron (over 1 per cent. phosphorus) constituted 88 per cent. of the total, with 10 per cent. hematite iron and 2 per cent. other grades.

The 1921 steel output showed an increase of 1.7 per cent. over that of 1920, a remarkable achievement as compared with other countries.

The depression in the metallurgical industry, which began in the latter part of 1920, reached its culminating point last September. Shortly afterwards the number of unfilled orders began to increase. A certain number of blast-furnaces, which had been extinguished during the preceding months, were relighted. Prices became firmer and afterwards showed a rising tendency. The daily deliveries of German coke decreased in the latter part of the year from approximately 15,000 tons to about 8600 tons. The lack of coke, which is restricting production, is perhaps the initial cause of the recent rise in prices. Although these prices, considering the cost of production, are not excessive, a further movement in that direction might check a prevailing tendency to better conditions. If sufficient coke can be obtained, considerable progress will be made in 1922 toward a return to normal conditions.

An idea of the potential production of France may be obtained from the fact that, on Dec. 31, 1921, France possessed 220 blast-furnaces, of which 85 were in the Nancy district and 66 in Alsace-Lorraine. Of the total, 54 were active, 23 of which were in the Nancy district and 16 in Alsace-Lorraine; 96 were idle, 32 being in the Nancy district and 33 in Alsace-Lorraine; 70 were under construction or undergoing repairs, of which number 30 were in the Nancy district and 14 in Alsace-Lorraine.[1]

In accordance with the new railway rates a reduction will be made in transportation charges on iron ore, pig iron, and half-finished products. Metallurgical products intended for exportation will also enjoy lower

[1] *Comm. Rept.*, Mar. 13, 1922.

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rates. These reductions will facilitate a greater development of foreign trade.

In this connection it should be noted that in spite of world-wide depression, France succeeded in increasing its exports of metallurgical products in 1921. The following are the principal French imports and exports of iron and steel products in 1921:

IRON AND STEEL IMPORTS INTO FRANCE
(In metric tons)

	1913.	1918.	1919.	1920.	1921.
Pig iron	32,669	375,941	95,097	112,168	37,875
Blooms, billets and bars	19,379	973,552	523,940	429,293	161,721
Wire rods	6,903	52,483	31,594	28,239	10,727
Plates and sheets	13,760	218,295	261,613	272,631	227,806
Tin-plate	19,460	58,192	40,800	75,592	13,179
Wire	6,088	33,288	28,972	13,113	7,610
Rails	1,792	156,861	217,743	27,430	12,736
Totals	100,051	1,868,612	1,199,759	958,466	471,654

IRON AND STEEL EXPORTS FROM FRANCE
(In metric tons)

	1913.	1917.	1918.	1919.	1920.	1921.
Pig iron	99,730	17,433	6,999	129,544	287,551	653,209
Blooms, billets, and bars	313,741	32,087	14,568	72,925	344,305	606,335
Sheets and hoop iron	11,944	4,148	3,277	6,706	23,856	40,144
Tin-plate	2,283	727	758	1,119	3,064	2,743
Wire	5,613	1,535	961	2,041	28,812	19,146
Rails	75,689	489	1,023	8,703	55,983	137,588
Totals	509,000	56,419	27,586	221,038	743,571	1,459,165

The production of iron ore in France during 1919, 1920, and 1921 was as follows, according to *Annales des Mines:*

Field.	Metric Tons. 1919.	Metric Tons. 1920.	Metric Tons. 1921.
Metz-Thionville	7,127,472	8,074,989	7,826,674
Briey-Longwy	809,229	4,181,229	4,823,096
Nancy	669,645	816,201	605,644
Total Lorraine	8,606,346	13,072,429	13,255,414
Normandie	322,929	357,200	511,923
Pyrénées	257,095	213,782	115,965
Other fields	243,419	227,786	233,404
Total	9,429,789	13,871,187	14,116,706

Stocks on Dec. 31 totaled 4,382,282 tons for 1921, against 3,988,705 tons for 1920.

Exports of French iron ore in 1921 (and 1920 respectively) included: To Germany, 1,390,223 (1,145,759) tons; Belgium, 1,140,814 (1,582,686) tons; Luxemburg, Saar district, etc., 2,766,883 (2,111,079) tons; total, 5,297,920 (4,839,524) tons.

The total iron-ore imports in 1921 were 425,026 tons, as compared with 404,724 tons in 1920 and 303,852 tons in 1919. The 1921 imports included 114,106 tons from Spain and 185,033 tons of silicious ores from Luxemburg.

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The work of restoration at the war-damaged mines was pursued energetically during 1921, and is now practically completed. The increased volumes of water that will have to be dealt with, however, will remain as a souvenir of the German invasion.

An article, "Evolution of French Iron and Steel," by Joseph F. Shagden, in *The Iron Age*, June 16, 1921, deals with post-war problems and other important matters.

Germany.—No official statistics of the German steel industry have been made public since late in 1919. For some reason publicity has been halted and the world is still ignorant as to just what the magnitude of the industry is at present. The latest data published was from the Berlin correspondent of *The Iron Age*, published in that journal Jan. 19, 1922, in part as follows:

No detailed statistics covering Germany's iron and steel production during 1920 and 1921 have been published as yet. While some headway has lately been made in bringing the foreign-trade returns for the current year up to date, production statistics are still lagging sadly behind. This delay must primarily be attributed to the lack of personnel at the offices of the federal bureau of statistics during the years of the war, as a result of which material has accumulated to an extraordinary extent.

The latest returns on record cover the year 1919, which in many respects will go down as one of the most exceptional years in the annals of the German industry. War had just come to an end, but peace had not been concluded, the army was in a state of collapse and disintegration, and the entire industrial apparatus in the course of reconstruction.

Beginning with ore mining, the total tonnage of iron ore raised is given as 6,153,800 tons as compared with about 28,600,000 tons in 1913. Of blast-furnace plants there were 69 with 232 furnaces toward the end of the year, the respective figures for 1918 and 1913 being 23 and 267, and 93 and 330. Consumption of iron ores and ferro-manganese, including manganese ores with more than 30 per cent. manganese, at the furnaces amounted to 10,592,000 tons as against 38,534,000 tons in 1913 and 18,-048,000 tons in 1918. A feature of the ore supply was the notable relative increase of Scandinavian shipments and the heavy decline in the consumption of manganese ores.

Production of coke and charcoal pig iron totaled 5,650,000 tons, comparing with an output of 9,208,000 tons in 1918 and 16,760,000 tons in 1913. The number of iron and steel foundries decreased from 1574 in 1913 to 1469 in 1918 and 1468 in 1919; the number of employees from 154,300 to 123,930 in 1918, but increased to 135,000 in 1919.

At the end of 1919 there were 99 steel plants, while 108 were in existence in 1918 and 106 in 1913. The decrease in the means of production is shown in the tabulation below:

Year.	Converters.		Open-hearth Furnaces.	Electric Furnaces.	Crucible Furnaces.
	Basic.	Acid.			
1919	64	15	451	38	71
1918	82	23	505	46	81
1913	109	13	432	27	116

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The decrease is chiefly due to the cession of Alsace-Lorraine and the temporary elimination of the Saar district, the total production in Lorraine, the Palatinate and the Saar district amounting to 4,400,000 tons or 25.7 per cent of the German total. The total output for 1919 was 6,877,600 tons only against 11,829,000 tons in 1918.

The number of rolling mills in existence in 1913 declined from 174 to 153 in 1919. The subjoined table shows the relation in the production of semi-finished material and finished products in metric tons:

Year.	Semi-finished.	Finished.
1919	1,132,000	5,230,000
1918	2,028,400	8,775,000
1913	2,958,000	13,119,000

As already stated, no detailed returns for 1920 have been issued yet. According to a statement by the Verein Deutscher Eisen und Stahl Industrieller (Federation of German Iron and Steel Industries), 5,550,000 tons of pig iron and 7,710,000 tons of steel were produced in 1920. If these figures are correct, they would indicate a decline in iron output of 104,000 tons compared with the 1919 production (using the figures of the bureau of statistics for the comparison) and an increase in steel production of 978,000 tons over 1919.

These data cover Germany proper and evidently do not include Lorraine and Luxemburg.

Complete data on pig iron, so far as now known, and for recent years, are as follows:

	Metric Tons.					
	1914.	1915.	1916.	1917.	1918.	1919.
January	1,566,505	874,133	1,078,368	1,082,797	933,570	506,185
February	1,445,511	803,623	1,036,683	943,547	892,788	475,586
March	1,602,896	938,438	1,114,194	1,104,653	1,039,092	558,788
April	1,534,429	938,679	1,073,716	1,131,620	1,084,601	439,975
May	1,607,193	985,968	1,112,574	1,198,171	1,181,794	524,986
June	1,531,333	989,877	1,079,349	1,124,998	1,182,415	531,632
July	1,564,345	1,047,503	1,133,092	1,190,014	1,179,947	580,819
August	586,661	1,050,610	1,145,239	1,185,968	1,155,084	568,785
September	580,087	1,034,124	1,116,752	1,119,635	1,105,366	531,167
October	729,882	1,076,343	1,161,005	1,076,222	1,049,837	.....
November	788,956	1,019,122	1,101,311	1,007,731	516,570	.....
December	853,881	1,029,144	1,161,955	1,976,891	430,478	.....
Total	13,191,679	11,787,564	13,314,238	13,142,247	11,754,542	5,654,408

Production of pig iron by kinds for several years past is noted below. Steel pig includes ferromanganese, spiegeleisen, ferrosilicon, and similar alloys:

	1912.	1913.	1914.	1915.	1916.	1917.	1918.	1919.
Foundry iron	3,355,177	3,640,074	2,494,832	2,283,538	2,019,991	2,012,227	2,499,882	1,372,469
Forge iron	525,423	489,783	370,257	278,684	216,693	246,288	173,019	104,576
Steel pig	2,201,489	2,599,887	1,996,786	1,793,865	2,380,308	2,446,092	2,255,312	1,521,390
Bessemer pig	388,855	368,840	237,988	187,522	152,660	130,019	115,689	61,018
Thomas pig	11,397,965	12,193,336	9,289,989	7,246,322	8,515,086	8,307,571	6,763,592	2,593,607
Total	17,868,909	19,291,920	14,389,852	11,789,931	13,284,738	13,142,247	10,807,494*	5,654,215

* Ten months.

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The following table gives the production according to districts:

PRODUCTION ACCORDING TO DISTRICTS
(In metric tons)

	1914.	1915.	1916.	1917.	1918.
Rhenish-Westphalia	6,610,119	5,165,618	5,749,806	5,932,914	5,817,886
Siegerland and Hessen-Nassau	702,436	789,650	868,544	767,800	702,377
Silesia	853,957	777,625	784,052	751,805	909,506
North and Central Germany	734,659	602,826	663,658	860,878	771,123
South Germany and Thuringia	266,065	234,669	255,325	168,627	168,315
Saar District	954,738	801,597	944,730	898,350	708,863
Lorraine and Luxemburg	4,267,573	2,407,946	4,018,615	3,561,873	2,677,890
Total	14,389,547	11,789,931	13,284,730	13,142,247	11,755,960

The statistics of the German output of steel for recent years, compared with those for 1913, are as follows:

	1913.	1916.	1917.	1918.	1919.
Basic Bessemer	10,629,697	7,653,990	7,294,899	5,906,460	2,388,421
Open-hearth	7,610,140	6,856,801	7,274,473	6,170,781	4,205,412
Bessemer (acid)	155,138	175,109	173,430	146,424	44,190
Crucible	99,173	108,205	129,784	79,064	38,294
Electric	101,755	190,036	219,700	221,824	55,382
Steel castings	298,338	1,198,379	1,495,074	1,232,260	145,699
Total	18,894,241	16,182,520	16,587,360	13,756,813*	6,877,398

* Ten months.

The total production of rolled steel in 1919 is given as 6,362,543 tons, of which 1,132,257 tons was semi-finished steel.

At the close of 1919 there were 232 blast-furnaces in existence, of which 152 were operating. The number of open-hearth furnaces was 451 making ingots and 143 making steel castings. Total electric furnaces were 38 on ingots and 13 on steel castings.

Exports of iron and steel were as follows so far as data are obtainable, in gross tons per month:

Year.	Exports.
1912	482,400*
1913	516,900*
1920	143,600
1921	203,681†

* Including Luxemburg. † Eight months only, May to December.

Great Britain.—The statistical bureau of the National Federation of Iron and Steel Manufacturers has issued the following table of production of pig iron by grades, in long tons:

	1918.	1919.	1920.	1921.
Forge	772,321	.....	2,094,700	976,700
Foundry	1,296,394	.....		
Basic	3,166,556	.....	2,661,700	687,200
Hematite	3,538,435	2,374,000	2,941,900	850,500
Spiegeleisen, ferromanganese and ferrosilicon	246,943	2,782,000	336,400	97,000
Direct iron castings, etc	18,780	2,242,000*		
Total	9,039,429	7,398,000	8,034,700	2,611,400

* Includes foundry and forge iron, alloys, etc.

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Production of pig iron for a number of years past has been as follows:

	Tons.		Tons.
1908	9,289,840	1915	8,793,659
1909	9,664,287	1916	9,047,983
1910	10,217,022	1917	9,420,254
1911	9,718,638	1918	9,039,429
1912	8,889,124	1919	7,398,000
1913	10,481,917	1920	8,034,700
1914	9,005,898	1921	2,611,400

The following table gives the output of steel ingots and castings in Great Britain, in gross tons:

BRITISH STEEL OUTPUT BY GRADES

	Electric.	Acid Bessemer.	Basic Bessemer.	Acid Open-hearth.	Basic Open-hearth.	Total.
1913	.....	1,043,772	551,929	3,811,383	2,251,793	7,663,876
1914	.....	797,072	483,444	3,680,843	2,874,749	7,835,113
1915	.....	831,408	479,816	4,090,752	2,958,968	8,550,015
1916	.....	1,096,153	505,817	4,393,004	3,012,558	9,196,457
1917	57,156	1,059,281	602,265	4,413,843	3,421,170	9,553,715
1918	103,021	788,355	567,650	3,901,136	3,924,415	9,284,577
1919	77,000	493,000	384,000	2,960,000	3,847,000	7,894,000
1920	55,200	552,500	375,500	3,302,100	4,574,900	9,067,300*
1921	27,100	168,300	123,300	1,154,100	2,063,700	3,625,800*

* Includes "all other steel castings."

The large proportion of basic open-hearth steel made in 1921 is the feature of last year's data.

IRON AND STEEL EXPORTS, UNITED KINGDOM
(In tons of 2240 lb.)

	1915.	1916.	1917.	1918.	1919.	1920.	1921.
Pig iron	508,540	790,065	639,261	416,861	356,955	579,509	135,998
Wrought iron	.....	138,095	64,941	41,930	36,337	.....	.....
Sheets	286,466	277,206	172,139	115,397	133,812	138,462	48,688
Plates	.....	311,452	115,765	112,530	238,551	198,831	128,082
Rails	242,289	50,275	39,000	26,559	125,216	130,743	176,381
Steel shapes, etc.	489,464	617,159	428,445	6,565	38,652	.....	.....
Tin-plates	368,000	321,654	177,383	223,474	289,462	353,058	226,482
All other kinds	1,252,540	850,433	685,849	.....	.....	1,895,244	1,022,985

Hungary.[1]—Prior to the partition of Hungary in accordance with the Treaty of Trianon, the country possessed iron-ore deposits estimated to contain 144,000,000 metric tons of ore, whereas the amount of this mineral in present Hungary is placed at 5,650,000 tons, the remainder now being located in Czecho-Slovakia.

The Hungarian Bureau of Mines is pessimistic over the future of the domestic iron-ore production, stating that the present supply can last only 10 years longer and that the discovery of new deposits of importance is unlikely.

The present exploited deposits are located in the northern section of the county of Borsod, about 160 miles from Budapest, near the Czecho-Slovak border. This district occupies an area of approximately 1⅔

[1] *Comm. Rept.*, May 1, 1922.

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square miles. The mines were operated until July, 1921, at which time production was suspended, the majority of the miners obtaining employment in the coal-mining districts of the country.

Production of iron ore in 1921 amounted to but 36,015 metric tons, against 394,962 tons in 1913, or a decrease of 358,947 tons. The 1921 output was produced in the Telekes-Rudabanya, in the county of Borsod, but is inferior in quality to that from the Czecho-Slovakian deposits.

There were no exports of iron ore in 1921. Imports amounted to 33,429 metric tons, 33,179 tons of which came from Czecho-Slovakia. In 1913 Austria supplied 76,175 tons of the 86,055 tons imported. Stocks of iron on hand at present approximate 136,500 tons, the bulk of which is reported to be in Budapest.

India.—India, during the next five years, will witness considerable development and growth in its metallurgical industries, particularly those of iron and steel, in the opinion of Mr. S. M. Marshall, consulting engineer for the Tata Iron & Steel Co., who has recently made a study and survey of railway traffic as relating to these industries. Plans have been drawn up for extensions to existing mills and new plant construction, all for completion and operation during this period.

At the present time there are only three industries of this kind in operation: The Bengal Iron Co., at Kulti on the East Indian Railway, the Tata Iron & Steel Co., at Tatanagar on the Bengal-Nagpur Railway, and the Cape Copper Co., at Rakha Mines on the same railway. There are, however, three large new plants under construction or in serious contemplation. These are the Indian Iron & Steel Co. near Asansol, the Eastern Iron Co., whose plant will probably be located near Chandil on the Bengal-Nagpur line from Sini to Adra, and a third company whose plant will probably be at Manharpur on the same railway.

In addition to these, the three existing plants have extensions under way or planned. Furthermore, a number of similar industries are locating near the works of the Tata Iron & Steel Co. At the present time eight of these subsidiaries are proceeding with their construction, and several others are under immediate contemplation.

The iron ore and coal come from the same districts for all the iron and steel companies. The two main coal fields are located east and west of the Bengal-Nagpur line to Asansol. The iron ores are located in Manbhum, Singhbhum, Keonjhar, and Bonai States and lie immediately south of the main line for a distance of about 100 miles from Tatanagar to beyond Manharpore. The flux for the companies largely comes from points on the same railway west of Manharpore, although a small quantity is secured on the East Indian Railway near the Sono River.[1]

[1] *Comm. Rept.*, Oct. 24, 1921.

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The Indian Iron & Steel Co.'s plant will be ready for operation in 12 months, and the extensions of the Tata Iron & Steel Co. will start progressively within the next two years.

Plant location and products of manufacture of the present and new companies are shown in the following list:

Company.	Location.	Products.
Bengal Iron Co	Kulti	Pig iron.
Eastern Iron & Steel Co	Chandil	Pig iron and steel.
Indian Iron & Steel Co	Burnpore	Pig iron.
Tata Iron & Steel Co	Tatanagar	Pig iron and steel.
Calcutta Monifieth Works	Tatanagar	Jute mill machinery.
Indian Steel Wire Products	Tatanagar	Wire and pressed metal products.
Truscon Steel Co	Tatanagar	Concrete reinforcing material.
Enameled Ironware, (Ltd)	Tatanagar	Enameled hollow ware.
Indian Enfield Cable Co	Tatanagar	Electric cables.
Tin Plate Co. (of India)	Tatanagar	Tin-plate.
Agricultural Implements Co	Tatanagar	Hand agricultural tools.

When this extensive program is carried to completion it is expected that Indian iron and steel companies will be in a fair way toward satisfying the enormous domestic demand and perhaps permit of some exportation to the Far East and near-by markets. Indian furnaces have supplied Japan with large quantities of pig iron and may look for a continuance of this business.

PRODUCTION OF IRON AND STEEL IN INDIA (a)
(In long tons)

	Iron Ore.	Pig Iron.	Ferro-manganese.	Steel.
1916	411,809	244,710	1,843	131,292
1917	413,357	248,132	1,475	162,711
1918	492,669	248,018	13,233	182,269
1919	563,750	307,374	2,650	186,901
1920	558,005	317,639	1,183	156,240

(a) *Mining Mag.*, July, 1921.

In the testimony he gave nine years ago this month in the Government's suit against the Steel Corporation, President James A. Farrell referred to India as one of the foreign countries which could send pig iron to the United States and undersell American manufacturers.[1] At the time he testified a shipload of pig iron was on its way from Calcutta to San Francisco, the first pig iron coming from India to the United States. The cost of this pig iron at the furnace in India was put at $5.40 a ton; the freight-rate to Calcutta was 48 cts. By sailing vessels the rate from Calcutta to San Francisco was from $5 to $6.50 per ton. Thus the cost of Indian pig iron at that time, plus the rate to San Francisco was but little more than the freight of $10.08 per ton then existing on pig iron from Birmingham, Ala., to San Francisco.

Mr. Farrell's testimony is recalled in view of an article which has just appeared in the London *Ironmonger*, saying that India will be in a position to produce the cheapest steel in the world. India is one of the largest buyers of British iron and steel, and the London paper suggests that these

[1] *Iron Age*, May 11, 1922.

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new enterprises may result in a serious diminution in British export trade.

India has been and is an importer of steel on a large scale, chiefly from Great Britain. In 1913 the combined British and American iron and steel exports to India averaged 69,000 gross tons per month. In 1919 they were 32,500 tons a month. There was an advance to 62,200 tons per month in 1920 and a decline to 42,900 tons per month in 1921. British manufacturers contributed 96.8 per cent. of the total from the two countries in 1913 and last year 83.9 per cent.

A writer in the London *Iron and Coal Trades Review*, in saying that in the last 10 years India has been coming forward as a rival to the United States in low cost of producing iron and steel, ventures the opinion that eventually she may challenge all other countries except the United States in the matter of output. It should be easily possible for the steel works of India, in the next few years, to reach a position where they could supply all the needs of that country. The probabilities are that not only will this come to pass, but that India will become a competitor of Great Britain and the United States for iron and steel business in non-producing countries.

An extensive article on "The Iron and Steel Industry of India" by J. Coggin Brown, officiating superintendent, Geological Survey of India, is published in *The Mining Magazine* for July, 1921.

Italy.—Production of pig iron for 1920 in Italy showed a falling-off of 63 per cent. from that of 1919, with a further fall of 32 per cent. in 1921, the decline having been caused principally by lack of raw materials and by labor difficulties. Steel ingots and castings made the small gain of 6 per cent. in 1920, but a loss of 12 per cent. in 1921. The tonnage for the three years was as follows, in metric tons:

Articles.	1919.	1920.	1921.
Pig Iron.			
Coke	198,825	52,274	26,900
Charcoal	11,828	11,239	8,100
Synthetic (electric furnaces)	29,057	24,550	25,400
Total pig iron	239,710	88,063	60,400
Steel.			
Ingots:			
Martin	627,595	633,537	.....
Electric	64,982	94,094	.....
Castings:			
Martin	13,034	18,570	.....
Bessemer	300	276	.....
Robert	2,070	2,000	.....
Electric	23,842	26,284	.....
Total steel	731,823	774,761	683,200

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The past year has been without doubt one of the worst Italian industry has known, although the depression which hit all the great countries of the world did not affect so much the Italian steel companies, thanks to the high exchange and to the revision of the custom tariff. Duties were increased to such an extent as practically to prevent any import from abroad.[1]

From the financial point of view, however, the year 1921 was a very bad one and there were two notable downfalls among the big steel manufacturers of Italy—Ansaldo and Ilva. These two concerns, which had a capital of over 800 million lire, broke down on account of the impossibility of carrying out their farreaching programs, which were conceived during war time.

Apart from a few, the Italian steel plants have had a temporary agreement under the leadership of the Società Esercizi Siderurgici e Metallurgici, whereby prices of steel commodities are fixed by mutual consent. The prices are regulated according to foreign competition and exchanges. In this way the steel companies avoid underbidding each other, but it is feared that the arrangement will be disturbed sooner or later by the tariff revision, which is strongly advocated by a number of members of the Chamber of Deputies, especially by the Agrarians.

One of the chief obstacles to the return of the Italian industry to normal activity has been the deficiency of electric power due to the persistent drought of this winter. Most of the Italian plants are operated by hydro-electric stations.

Owing to the bad times and to the lack of proper financing, little or nothing has been done by the Italian steel companies in the line of remodeling their plants. No new furnaces or rolling mills have been added to those existing nor have any efforts been made to set in motion the idle ones which were started during the war and shut down shortly after the signing of the armistice.

The amount of iron ore existing in Italy is estimated at about 40,000,000 tons and is irregularly distributed. Production in 1921 was 279,980 metric tons, compared with 389,966 tons in 1920 and 613,093 tons in 1919.

Japan.—The Yawata (Government) Steel Works, in Kiushiu, is now building a mill to manufacture billets for private steel makers. Press dispatches state that the construction program calls for completion of the plant about April, 1924, when a productive capacity of 200,000 tons of billets per year is expected.

The output of the Yawata Steel Works for 1919 amounted to 610,000 tons of pig iron and 550,000 tons of steel. In 1921 the output was 500,-

[1] *Iron Age*, Apr. 27, 1922.

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000 tons of pig iron and 530,000 tons of steel. An official of this company stated that foreign iron and steel are imported and sold at lower prices than the Japanese manufacturers can meet, and that the armament limitations would reduce the output of finished steel by about 60,000 tons annually.[1]

During the early months of 1921 the industry was confronted with its worst crisis, and at one time during the summer it was proposed by some ironmasters to render easier the position of the industry through the merger of all mills. This proposal was at once dropped because of some difficulties that were foreseen.

The proposal for a merger of the iron works has again been revived, evidently because of the proposed naval holiday and its effect on the industry and also because of the uncertainty regarding the general revival of business. A short time ago representatives of several leading furnaces held a conference to discuss their present difficulty. As a result, the conclusion was reached that the only way open to them is to combine and readjust all Japanese furnaces.

Iron and steel imported into Japan in 1921 amounted to 1,412,881 long tons, as compared with 2,046,247 tons in 1920 and 1,662,804 tons in 1919.

Only 33,807 long tons of iron and steel were exported from Japan in 1921, which was a loss from the export trade of the two previous years, when exports amounted to 48,413 tons and 37,322 tons in 1919 and 1920, respectively.

Jugo-Slavia.—An article on "The Iron Ores of Jugo-Slavia," by D. A. Wray, geologist to the British Mission in 1919, appeared in the *Mining Magazine* for March, 1922.

Luxemburg.—Luxemburg previous to the war was no small factor in the world's output of steel and iron, ranking equal to Belgium in 1912 and 1913. Like Belgium, it suffered severely from the war's devastation and its recovery in productive efficiency has been slow. In the first ten months of 1921 pig-iron and steel output reached an average of 76,180 and 59,690 gross tons per month, respectively. In 1920 the figures were 58,000 tons per month for pig iron and 49,000 tons for steel. In 1913, however, Luxemburg produced 209,000 tons per month of pig iron and 109,000 tons per month of steel. In the last two months reported—September and October of 1921—the recovery had reached more than 90,000 tons per month for pig iron and nearly 80,000 tons per month for steel, considerably exceeding Belgian output and nearly twice that of Canada.[2]

[1] *Japan Advertiser.*
[2] *Iron Age*, Feb. 2, 1922.

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The following table shows the iron and steel production since 1913 in metric tons:

	Iron Ore.	Furnaces in Blast.	Pig-iron Production.	Output of Steel.	Output of Castings.
1913	7,333,372	45	2,547,861	1,182,227	26,513
1914	.....	47	1,827,270	1,136,495	22,954
1915	.....	47	1,590,773	980,384	16,649
1916	.....	47	1,950,514	1,296,407	24,578
1917	.....	47	1,528,865	1,053,596	23,601
1918	.....	47	1,266,671	857,937	19,906
1919	3,112,472	..	617,422	366,231	.....
1920	3,704,390	..	692,935	569,545	.....
1921	.....	..	955,200	747,600	.....

Newfoundland.[1]—It is reported from Essen that certain German companies, which made a trial of Newfoundland iron ore many years ago, have just concluded contracts for the delivery of 800,000 tons of Newfoundland Wabana ore, which is phosphoric ore and equally as suitable for the production of basic Bessemer pig iron as French minette or the French ore in Normandy. It is calculated that it will be possible to procure about 1,000,000 tons per annum of this ore from Newfoundland or Labrador. The price of the ore, contracts for which are said to have been entered into with three Wabana companies, is given at the low figure of 18s. 6d. c. i. f. Rotterdam.

Poland.—"The Iron and Steel Industry and Trade of Poland" is the title of an instructive supplement to *Commerce Reports* by H. B. Smith, acting American Commercial Attaché at Warsaw. It is published as Trade Information Bulletin No. 35, under date of June 19, 1922. The steel output for 1921 is given as 120,444 metric tons, as compared with 599,769 tons in 1913. Data on imports and exports of iron and steel are given in detail.

Polish Government statistics (unverified) give the output of iron ore in Poland as 238,000 metric tons in 1921, compared with 120,000 tons in 1920 and 330,057 tons in 1913.

The production of pig iron last year was only 20 per cent. of the prewar output. The industry depends for its coke supplies entirely upon imports from Teschen, as the Upper Silesian coke, although much cheaper, cannot be used for blast-furnaces. It was found possible, however, to keep in operation four large blast-furnaces and seven Martin furnaces, which gave employment to about 15,000 men. The production of pig iron amounted to 130,000 tons, and that of cast-iron goods, wire, thin and thick sheets, and pipes to 250,000 tons.[2]

The future of the iron and steel industry of Polish Upper Silesia, while apparently assured after a few years, is not regarded as optimistically for the immediate future as that of the coal industry, says A. B. Barber, technical adviser to Poland, in a statement received by the Department

[1] *Comm. Rept.*, Apr. 10, 1922.

[2] *Ironmonger* (London), June 17, 1922.

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of Commerce. This is due to the fact that a considerable part of the production must at present seek its market in Germany, while in the German market there is the difficulty which existed even before the war of meeting west German competition, chiefly on account of the long distance the greater part of the iron ore must be hauled to Upper Silesia and on account of the inferior strength of Upper Silesian coke when used in blast-furnaces (200 tons being a maximum charge as against over 400 tons with Westphalian coke). It is reported that today Westphalian pig iron can be laid down in Upper Silesia at a price lower than Upper Silesian pig iron. The Polish Silesian iron and steel industry will therefore for some time be dependent upon the condition of the industry in Germany, and to secure the Polish market will at times require protection by customs barrier against the German industry.

While the iron and steel production of Upper Silesia as a whole during the past decade has been constantly in the neighborhood of 1,250,000 tons per annum (of which 70 per cent. is on the Polish side), the Upper Silesian iron-ore production is rapidly becoming insignificant, having fallen to 53,000 tons in 1920. In 1912 the production was 165,000 tons, having decreased steadily from 706,000 tons in 1891.

Upper Silesia has always had to import the essential high-grade ore from Sweden or south Russia, and in recent years, owing to the exhaustion of the Silesian ores, has imported the greater part of her low-grade ores from Germany, together with up to 300,000 tons annually of scrap iron. Polish Upper Silesia will have to continue importing her high-grade ores, but it is expected that within 2 or 3 years the production of ore in the part of Congress Poland lying just to northeast of Upper Silesia (region of Czestochowa and northwest thereof), where the reserves are estimated at 300,000,000 tons, will be sufficiently developed to take the place of the exhausted Upper Silesian and imported German low-grade ores. During the intervening years, before the supply of iron ore from Polish and south Russian mines can be developed and the use of scrap iron replaced by the use of iron ore, the greatest difficulty for the iron and steel industry in Polish Upper Silesia will be to provide the necessary ore and scrap iron to maintain the production at the present rate. However, it is expected that, in the convention now being negotiated in accordance with the Geneva decision, Germany will undertake for a limited period to continue the supply of the necessary German ores and scrap iron.[1]

Russia.[2]—The outstanding feature of the operation in 1921 of the nationalized steel industry in Russia was the sharp fluctuation which marked the course of production by months, by regions and by commodities within the same plant units. The statistics obtained since 1917

[1] *Chem. Met. Eng.*, May 10, 1922.

[2] *Comm. Rept.*, May 22, 1922.

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were taken from the Soviet official press. The accompanying table shows the comparative production of pig iron, open-hearth steel and rolled steel from 1913 to 1921 inclusive. Open-hearth figures are for ingots and in rolled steel are included structural shapes, rails, plates and sheet metal, bars and angles and wire rods.

SOVIET FIGURES OF RUSSIAN IRON AND STEEL PRODUCTION

Years.	Pig Iron, Poods.	Open-hearth Steel, Poods.	Rolled Steel, Poods.
1913	257,000,000	259,000,000	214,000,000
1916	232,000,000	261,000,000	206,000,000
1917	165,000,000	188,000,000	149,000,000
1918	13,000,000	25,000,000	22,000,000
1919	7,000,000	12,000,000	11,000,000
1920	6,000,000	10,000,000	11,000,000
1921	7,000,000	10,000,000	12,000,000

In 1921 production reached a minimum in the third quarter. There then followed a marked increase in the last quarter, attributed by the Soviet press to the introduction of the "new economic policy," abolition of State rationing of labor, abandonment of the principles of wage equalization, and the introduction of straight tonnage pay and profit-sharing bonuses for the management of the works.

While the Soviet Government has retained operation of the basic steel industry, it has endeavored to transfer the operation of small mills and shops to former owners and co-operatives by leasing. Only 251 metal-working establishments, however, were leased out in this way in 1921, and these were mostly small shops producing hardware, nails and agricultural implements, etc.

The conditions of lease are as follows: (1) The concessionaires undertake to raise output to a previously fixed level. (2) Output to be divided as follows: 60 per cent. reserved for home market, 20 per cent. acquired through the Commissary for Export Trade, 10 per cent. bought by the State to furnish stocks for home trade, 5 per cent. reserved for the Soviet as landlord, and 5 per cent. distributed as premium. (3) The Government's portion of the net profits to range from 20 to 50 per cent., according to the importance of the industry. (4) Concessionaires to be granted every relief necessary for the safety of the industry, while on their side they are responsible for the food supply of their employees. (5) Preference to be given to the old owners of the works, or, failing these, to their employees.

Straits Settlements.—An iron-ore deposit, estimated at 10,000,000 tons, has recently been located in the district of Batu Pahat, Johore, Straits Settlements, according to *Eastern Engineering*. The ore is being shipped

[1] *Comm. Rept.*, Sept. 5, 1921.

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to Japan, but, as there are signs of coal in the same district, it is hoped that pig iron may eventually be produced locally.

Spain.[1]—The year 1921 was a disastrous one for Spanish mining and metallurgical interests. The iron-ore mines of Spain form the backbone of the commercial and industrial prosperity of the provinces of Vizcaya, Santander, Almería, and Huelva. The total exports of iron ore for the first eight months of 1921 only reached 1,162,583 metric tons, as compared with 3,501,988 tons in the corresponding period of 1920. The port of Bilbao, which in 1920 exported 1,856,438 tons from January to October, last year only exported 464,000 tons during the same period. The prolonged coal strike in the United Kingdom, through its effect on the British iron and steel industry, largely aggravated the situation, and it was not until December, 1921, that there were slight signs of revival, although the stocks of ore in Bilbao at the end of November were 1,600,000 tons. Germany has been taking increasing quantities of Bilbao rubio, but Algeria and Tunis are competing with Spain in export to the United Kingdom. One of the difficulties Spain finds in expanding her home industries and railway system is that a large quantity of the ore exported returns to the country manufactured into pig iron, sheets, machinery, and implements.

Without exception the Spanish blast-furnaces were working short time during 1921. The Compañía Siderúrgica del Mediterraneo has now completed the construction of its furnaces at Sagunto, and will shortly be able to produce very large castings. The Spanish company of Babcock & Wilcox has completed its works, and construction is proceeding on locomotives as well as on patent water-tube boilers. The new shops of the Sociedad Española de Construcción Naval at Reinosa have begun to supply special steels, forgings, and castings.

Sweden.—The Swedish iron and steel industry found 1921 an unsatisfactory year. Orders were few and far between, foreign competition (especially German) forced prices down to a very low level, and at the close of the year the situation was serious. On Jan. 1, 1922, only 22 of the 133 furnaces, 37 of the 201 Lancashire hearths, and 15 of the 80 Martin furnaces were in operation.

The production of pig iron in 1921 amounted to 312,973 tons, against 470,550 tons in 1920. Of smelting iron and ingots the production was but 230,900 tons, which was only 31 per cent. of the 1913 production. The rolled-iron output was 122,900 tons, which was about 30 per cent. of the 1913 output.

The exports of iron and steel declined to 147,644 metric tons in 1921 as compared with 273,028 tons in 1920 and 316,045 tons in 1913. Domes-

[1] *Ironmonger* (London), Mar. 25, 1922.

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tic demand was largely met by foreign products, which were sold in Sweden at prices below the Swedish cost of production. Imports in 1921 were 149,109 tons, compared with 323,550 tons in 1920.[1]

The output of iron and steel in Sweden in 1918, 1919 and 1920, according to the statistics of the Swedish Iron & Steel Association, was as follows, in metric tons:

	1918.	1919.	1920.
Pig iron	674,900	497,400	452,300
Puddled iron	92,000	62,300	59,000
Bessemer steel ingots	66,500	56,900	50,300
Open-hearth steel ingots	458,300	412,400	367,100
Rolled and forged iron and steel	361,400	316,900	281,000
Crucible and electric ingots	.....	13,100	9,200

The average pig-iron output during the 8 years, 1912 to 1919, was 679,800 tons.

Switzerland.—The activities of the Research Society for the Utilization of Swiss Ore Deposits, founded in 1918, have led to the discovery of an important iron deposit in the Fricktal (Jura argovien). Test operations over a surface of 470 acres have confirmed the existence of iron ore deposits of over 15,000,000 tons, while another lot is roughly estimated to contain over 22,000,000 tons. The deposits are supposed to extend over a surface of about 2000 to 2400 acres, of which 910 have already been prospected. On a pre-war basis of consumption, 15,000,000 tons would suffice to keep Switzerland supplied with ores for about 45 years. The ores are oölitic, analogous to those to be found in the Lorraine. They contain iron varying from 27 to 35 per cent., or an average of 30 per cent.

Competent experts hold that the only advantageous manner of smelting the newly-discovered Swiss ore would be by means of electric furnaces. A special mission was sent from Switzerland in 1919 to study the working of the electric furnaces in Sweden. A company is being formed for the purpose of exploiting the Fricktal mines, in which the Confederation is expected to participate to the amount of 1,200,000 francs on the understanding that the capital of the company amounts at least to 4,000,000 francs.

Tunis.[2]—The Société du Djebel-Djerissa shipped 152,606 tons of ore in 1921, as compared with 291,593 tons in 1920. The Mokta-el-Hadid Company report that in 1921 British concerns, who are the company's principal customers, have reduced their purchases to about 54 per cent. normal. The output of iron ore in 1921 was only 246,947 short tons (as against 533,720 tons in 1920), and shipments totaled only 225,250 short tons in 1921, as against 607,354 tons in 1920.

Union of South Africa.[3]—For a number of years there has been considerable talk in South Africa in regard to developing the iron and steel

[1] *Comm. Rept.*, Mar. 13, Apr. 17, 1922.
[2] *Iron & Coal Tr. Rev.*, Mar. 12, 1922.
[3] *Comm. Rept.*, Jan. 30, May 1, May 15, 1922.

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industry in the Union by constructing a steel plant with a capacity sufficient to supply a substantial portion of the local demands, in order to cut down the large imports of steel and steel products as much as possible. There are important deposits of first-class iron ore and an abundance of coal found in South Africa within reasonable distance of each other that might make it profitable for at least one good steel plant. Deposits of high-grade ore have been proved of sufficient quantity to carry on the industry for 50 or 60 years, while other sources are expected to be developed.

Up to the close of the year 1921 the exhaustive plans of the South African Iron & Steel Corporation had not yet materialized and the productive equipment had not reached beyond that acquired from the Pretoria Iron Works. Over two-thirds of the authorized capital of £1,500,000 remained unsubscribed, and in view of the depression prevailing at present throughout South Africa there appears to be little hope that the great iron and steel industry planned by the promoters will become a reality in the very near future. Efforts to get capital in other countries have not been successful. Quite recently the corporation's properties were visited by English steel experts who expressed themselves as favorably impressed with the prospects of this venture. Until economic conditions throughout the world become stabilized and the corporation can obtain the necessary capital and produce steel on a competitive basis, no material results can be expected.

The operations of all the steel mills in South Africa resulted in a production of 21,988 gross tons of steel goods in 1921. The industry gave employment to an average number of 285 white men and 866 colored laborers.

The production of iron ore in South Africa in 1920 amounted to 2564 tons, valued at $3,947, and in 1921 to 2416 tons, valued at $3,353.

Pig iron can be produced in the Union of South Africa at a cost of 17s. 6d. per ton, according to Mr. G. H. Blenkinsop, who is quoted by the *South African Mining and Engineering Journal* as an authority. At this figure it would be possible for the Union to manufacture pig iron and to lay it down in the United Kingdom and on the Continent at much less than the cost of production in Europe and England. A few months ago this expert made a survey of the prospects for the establishment of an iron and steel industry in South Africa. At that time he came to the conclusion that the erection of blast-furnaces for the manufacture of pig iron was not commercially feasible, inasmuch as the Union lacked a supply of coking coal in commercial quantity.

Since then, however, the invention of a process known as the "froth flotation as applied to the washing of industrial coal," if applied to colliery

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smalls produced by local collieries, and the carbonization of coal at low temperatures would permit the manufacture of a bright, hard coke. The Union does possess large resources of high-grade acid iron ores and also high-grade basic iron ores containing from 0.25 to 0.30 per cent. phosphorus.

An article on "The South African Iron Industry," by E. E. Buttner, appears in the *South African Mining and Engineering Journal*, Nov. 19, 1921.

Technology

Achievements in the technology of the steel industry in 1921 were quite numerous, some of them of minor nature and others of distinct importance. The most vital are briefly reviewed in the following.

Electrolytic Iron.—From a mining or ore standpoint the most striking development was the announcement late in 1921 of the perfection of a new electrolytic process for making iron, particularly pure iron tubes. It involves the use of pyrrhotite, a complex sulphide of iron, which is decomposed by chloride of iron with the production of sulphur and copper as by-products. Electrolysis of the resulting iron chloride produces a pure iron of unusual properties. The process is also cyclical. A complete description written by Bradley Stoughton was published in *The Iron Age*, Jan. 5, 1922.

Stainless Iron.—Further progress in the manufacture of stainless products was made last year. British interests announced late in the year the bringing out of what they called "stainless iron, for the lack of a better name." It is low-carbon stainless steel, under 0.10 per cent. carbon. It is an electric-furnace product. The chief advantage claimed for it over stainless steel for cutlery is its marked malleability. Because of this it is being wrought or rolled into various shapes where non-corrodibility is a requisite. British sponsors for this material are enthusiastic over its possibilities and predict that it will ultimately be made cheap enough to compete with galvanized sheets, tin-plate, and wire products, ushering in the dawn of a "stainless age."

Titanium Ore in the Blast-furnace.—In blast-furnace developments one of the most interesting is some work done in Canada last year. It gives promise of being a long step toward a solution of the problem of smelting titaniferous iron ores successfully and economically. The details were published in the October, 1921, issue of *Iron and Steel of Canada*. Hitherto most attempts to reduce such ores have been based on the assumption that titanium acts as an acid in fluxing. While the results were successful in a measure, the operating difficulties as to slags were many. In the new experiments an entirely different basis was adopted. In Mendele-

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jeff's periodic table, some elements are basic and some acid, while others are neutral or amphoteric, capable of acting either way according to conditions. Titanium is one of the latter. The experimenters, by figuring their burden in such a way that in the resultant slag titanium acts as a base in a high-acid mixture, instead of an acid, show that high silica and titanium in iron ores may be a source of profit. In the new method of smelting, silica is added instead of lime. There is thus a saving in raw materials, the inherent titanium replacing lime. The resulting slags are reported to leave little to be desired, and the investigators hope that they have discovered the "germ of a radical yet sound departure in the commercial smelting of iron." If so, it means much to Canadian owners of iron ores as well as to some in this country.

Iron Castings Direct from the Blast-furnace.—Probably the first iron foundry to undertake to use molten iron direct from the blast-furnace on a large scale is the one operated by the Ford Motor Co. It is to have a final capacity of 2500 tons of castings per day. There are to be eventually 24 cupolas, part of which are now in operation. Castings have already been made commercially with up to 80 per cent. direct blast-furnace iron and 20 per cent. cupola metal, although a 50-50 ratio will be more probable. The cupolas are mechanically charged and the hot metal from the blast-furnaces is delivered to the foundry in 75-ton ladles. It is mixed in 20-ton mixer ladles, where it is mixed with cupola iron.

Largest Electric-steel Furnace.—In the starting up during 1921 of the Government ordnance plant at Charleston, W. Va., there was put into operation the largest electric-steel furnaces in the world, two of 50 tons capacity each. They are operated on the duplex plan, receiving hot refined metal from two 75-ton basic open-hearth furnaces. An article bearing on the quality of steel possible from such furnaces appeared in *The Iron Age*, Dec. 30, 1921. The starting up of these furnaces was pointed to as an epoch in electric steel.

A new induction electric furnace was discussed during the year. It has been brought out by the General Electric Co. and is a departure from former furnaces of this type in that the primary coil is placed above the crucible in order to remove it from possible damage due to a break-out.

Another development in the electric-steel industry has been the adoption by several manganese-steel casting producers of the electric furnace as a melting and refining medium.

Alloy Iron Castings.—Recent metallurgical developments point to the growing importance of alloy iron castings for industrial use. The unusual properties which a nickel content of 5 per cent. bestows on iron castings were discussed in *The Iron Age*, Aug. 25, 1921. Electrical-resistance castings containing 4 to 5 per cent. nickel have not only marked

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electrical properties, but the castings can be "twisted into various shapes, taking a permanent set without breaking." German experiments on iron castings containing nickel and cobalt show that a nickel content of about 1 per cent. bestows valuable properties, the cobalt, however, playing no role as an alloy. Attention has been called to the influence of a small percentage of nickel and chromium in chilled cast-iron wheels, and this may take on more importance. A large motor corporation is now making iron castings in the cupola, having a nickel content of 1 to 1.5 per cent. The nickel is introduced into the charge as shot nickel in the cavity of rejected pistons. The castings so obtained are harder and wear better than the ordinary gray-iron castings. The use of Mayari pig iron in the making of certain grades of castings is not new. Such nickel-chrome iron castings have proved satisfactory for rolls and for conditions where wearing quality is a factor. Extensive experiments are being made in order to learn all the possible uses to which this particular class of alloy iron castings can be put.

These facts point to the place which alloy iron castings are likely to take in the future. While some of these castings can be produced in the cupola, the electric furnace is necessary in cases where the alloy content is high or a high temperature is required for pouring. It is safe to expect that, with the aid of the electric melting furnace and possibly the application of heat-treatment, other metals besides nickel and chromium may be added to cast iron with good results, and that alloy iron castings may establish themselves alongside alloy steel castings.

Electric Furnaces for Heat-treatment.—Rapid strides have been made in the application of electricity to the heat-treatment of steel and iron. At least 80 furnaces of various types were employed late last year in this industry. Among the many products now heat-treated electrically, gray-iron castings are listed alongside of steel castings; also automobile and aircraft parts, sheets, bolts and nuts, and various other steel products. The application to non-ferrous materials is only in its beginnings. Also the use of electricity in the enameling and glass industries is quite extensive. The size and types of furnaces, many of them automatic, are a testimonial to the inventive ability of American electrical engineers. Equally noteworthy is the development of the pyrometric devices which are so vital an adjunct to this industry.

Hardness and Its Cause.—One of the most striking events in the field of pure theory has been the announcement of a new explanation of why metals and other materials are hard. It is known as the slip interference theory as promulgated by Dr. Zay Jeffries of Cleveland, Ohio, in collaboration with others. Details of the theory have been published in *Chemical and Metallurgical Engineering.*

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LEAD

By H. B. Pulsifer

The mine and smelter output of lead in the United States in 1921 each fell off about 20 per cent., according to the statement by C. E. Siebenthal and A. Stoll, of the United States Geological Survey, compiled from reports and estimates by producers and others. Data for the Western States are taken from the advance statements issued by the Geological Survey's western offices.

Mine Production of Lead.—The output of soft lead by mines of the Mississippi Valley was about 231,000 short tons, and that of argentiferous lead by mines of the Western States was about 170,000 tons, a total of 401,000 tons. The corresponding figures for 1920 are 251,816 tons from the Mississippi Valley (including the small output of the Eastern States) and 259,070 tons from the Western States, a total of 512,865 tons. The southeastern Missouri district made the largest output and was the only district to make a gain. Its output was 178,000 tons, as compared with 161,258 tons in 1920. The Coeur d'Alene district of Idaho came next, with about 96,000 tons, as against 118,105 tons in 1920. Utah made an output of about 45,000 tons, a decrease from 70,419 tons in 1920.

METALLURGICAL PRODUCTION OF LEAD IN THE UNITED STATES (a)

(Refinery statistics. In tons of 2000 lb.)

Year.	Domestic Origin.					Foreign Origin.		Grand Total.
	Desilverised.	Antimonial.	S. E. Mo.	S. W. Mo.	Total.	Desilverised.	Antimonial.	
1914.....	318,697	17,177	177,413	25,448	538,735	28,475	1,119	568,329
1915.....	305,160	24,601	185,849	20,312	535,922	43,301	2,883	582,106
1916.....	330,189	22,819	206,105	33,128	592,241	17,832	3,304	613,377
1917.....	319,015	16,265	205,861	40,575	581,716	50,962	2,991	635,669
1918.....	284,733	18,658	189,207	63,635	556,233	98,596	2,083	656,912
1919.....	226,085	14,864	158,182	55,790	454,921	61,380	1,547	517,848
1920.....	236,912	8,992	206,836	29,004	471,744	51,700	2,197	525,641
1921.....	202,649	5,419	142,304	56,155	406,896	47,697	2,361	456,954

(a) From *Eng. Min. Jour.*

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PRODUCTION OF REFINED PRIMARY LEAD IN THE UNITED STATES (a)
(In short tons)

	1917.	1918.	1919.	1920.	1921.
Domestic desilverized lead	303,679	282,024	208,751	220,327	187,962
Domestic soft lead	188,503	210,463	147,744	189,854	157,513
Domestic desilverized soft lead	56,268	47,418	67,938	66,668	52,747
	548,450	539,905	424,433	476,849	398,222
Foreign desilverized lead	62,319	100,290	57,787	52,808	50,367
Total refined primary lead	610,769	640,195	482,220	529,657	448,589
Production of antimonial lead	18,646	18,570	13,874	12,535	10,064

(a) U. S. Geol. Surv.

APPARENT CONSUMPTION OF REFINED PRIMARY LEAD IN THE UNITED STATES, REFINERY STOCKS DISREGARDED (a)
(In short tons)

	1917.	1918.	1919.	1920.	1921.
Supply:					
Stock in bonded warehouses, Jan. 1	535	2,685	472	234	1,322
Imports of pigs, bars, and old	5,793	5,240	5,107	35,719	31,301
Production	610,679	640,195	482,220	529,657	448,589
	617,007	648,120	487,799	565,610	481,212
Withdrawn:					
Exports of foreign lead—					
From warehouse	37,652	59,416	40,976	17,363	25,000
In manufactures, with benefit of drawback	7,537	3,426	1,936	6,175	9,369
Exports of domestic lead	53,688	41,831	10,510	2,730	1,624
Stock in bonded warehouses, Dec. 31	2,685	472	234	1,322	347
	101,562	105,145	53,656	27,590	36,340
Apparent consumption	515,445	542,975	434,143	538,020	444,872
Lead content of ore and bullion remaining in warehouse, Dec. 31 (b)	23,977	16,999	45,476	51,220	19,186

(a) U. S. Geol. Surv.
(b) Some part of this may have been smelted and thus included in the quantities given above as "Foreign desilverized lead."

Refinery Production of Lead.—The output of primary domestic desilverized lead in 1921 was 187,962 short tons, of soft lead 157,513 tons, and of desilverized soft lead 52,747 tons, making a total output from domestic ores of 398,222 tons of refined lead, as compared with 476,849 tons in 1920, which was made up of 220,327 tons of desilverized lead, 189,854 tons of soft lead, and 66,668 tons of desilverized soft lead. The output of lead smelted and refined from foreign ore and bullion was 50,367 tons, as compared with 52,808 tons in 1920. The total lead smelted or refined in the United States was thus 448,589 tons, as compared with 529,657 tons in 1920. The output of antimonial lead was about 10,064 tons, as against 12,535 tons in 1920.[1]

[1] Figures of the U. S. Geol. Surv. The figures compiled by *Eng. Min. Jour.* are also shown in an accompanying table, the difference being small.

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AMERICAN SILVER-LEAD SMELTING WORKS

Company.	Place.	Furnaces.	
		No.	Annual Capacity.
American Smelting & Refining Co	Denver, Col		
American Smelting & Refining Co	Durango, Col	3	200,000
American Smelting & Refining Co	East Helena, Mont	4	330,000
American Smelting & Refining Co	El Paso, Tex	4	275,000
American Smelting & Refining Co	Leadville, Col	8	510,000
American Smelting & Refining Co	Murray, Utah	8	700,000
American Smelting & Refining Co	Omaha, Neb	2	82,000
American Smelting & Refining Co	Perth Amboy, N. J	4	170,000
American Smelting & Refining Co	Pueblo, Col	7	380,000
American Smelting & Refining Co	Selby, Cal	3	210,000
Anaconda Copper Mining Co	Great Falls, Mont	1	90,000
Bullshead Mining & Smelting Co. (c)	Spruce Mtn., Nev., P. O. Reno	1	11,000
Bunker Hill & Sullivan M. & C. Co	Kellogg, Idaho	4	400,000
International Smelting Co. (a)	Tooele, Utah	5	600,000
Northport Smelting & Refining Co. (c)	Northport, Wash	3	265,000
Ohio & Colorado Smelting & Refining Co. (c)	Salida, Col	4	360,000
Pennsylvania Smelting Co	Carnegie, Pa	2	60,000
U. S. Smelting, Ref. & Mng. Co	Midvale, Utah	7	530,000
Totals, United States		70	5,173,000
American Smelting & Refining Co	Aguascalientes	2	90,000
American Smelting & Refining Co	Chihuahua	7	500,000
American Smelting & Refining Co	Monterrey, N. L	3	220,000
American Smelting & Refining Co	Velardena	3	150,000
Mazapil Copper Co	Saltillo, Coah	3	105,000
Cia. Metalurgica Mexicana	San Luis Potosi	10	360,000
Cia. de Minerales de Peñoles (b)	Cerralvo, N. L	2	38,000
Cia. de Minerales de Peñoles (c)	Monterrey, N. L	4	250,000
Cia. Minera de Peñoles (e)	Mapimi, Dur	(f)	(f)
Cia. Metalurgica de Torreone (e)	Torreon, Coah	4	200,000
Reforma Mining & Milling Co	Campo Morado, Gro	2	21,000
Totals, Mexico		40	1,934,000
Consolidated Mining & Smelting Co	Trail, B. C	4	220,000

(a) Idle latter part of 1921. (b) Not in operation since Jan. 23, 1917. (c) Not in operation in 1920 and 1921. (e) Subsidiary of Cia. de Minerales de Peñoles. (f) Dismantled.

Market and Consumption.[1] The year 1921 was probably the most unprofitable year for the lead miner since 1897. The average price for the last 25 years, f.o.b. cars New York, was 5 cts. per lb., as compared with 4.54 cts. for 1921. The price of lead in New York during December, 1920, was lower than in any month since October, 1915. Lead as a commodity has been liquidated. In four months, the price dropped from 8.90 to 4.50 cts. per lb., while the number of pounds of lead that could be produced for $1 on Jan. 1, 1921, was probably less than at any time in the history of lead mining in the United States. The cost of transportation in 1921 constituted a large part of the 4.54 cts. per lb. received for lead in New York. As an example, before the war it cost $100 to move a car of pig lead from East St. Louis to New York. In 1921. until Dec. 10, it cost slightly more than $330. Freight-rates on smelter products were advanced out of proportion to most of the other commodity rates.

[1] Irwin H. Cornell, *Eng. Min. Jour.*, Jan. 21, 1922.

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The pounds of lead produced for $1 should certainly increase to a limited extent in 1922, but the average price will have to be greater than 4.50 cts. New York to bring out a production of more than 400,000 tons from American mines. The price, although affected largely by the cost, must depend on, first, the tariff; second, on the consumption; and, third, on the visible and invisible stocks. The production will depend on the price.

A curve of price and production under the different tariff laws would prove without doubt that the Underwood tariff, except through extraordinary world conditions, would keep the price of lead below the point where the metal could be economically produced in this country under the present standard of wages and living conditions.

No accurate statistics concerning the consumption of lead in the United States by industries have been collected except by the United States Government agencies during the war, and these were never published. The consumption of lead must vary directly with the general business prosperity of the country, but by approaching each important industry separately, it is possible, from present conditions, to form some opinion concerning the probable demand for the metal in 1922. The most important question is whether the use of lead in the arts is decreasing or increasing. No substitute has replaced lead in any of the important industries in the United States, nor can it be argued that the present curtailment in demand is due in any way to the elimination of lead in manufactured articles.

Despite greatly disturbed business conditions, more white lead was manufactured and sold during 1921 than in any other year. There is reason to believe that the demand for lead pigments will gradually increase, although it will be remarkable if 1922 exceeds the record of 1921.

The storage-battery industry, which is second in importance to that of the paint industry, operated between 50 and 60 per cent. of capacity in 1921. The outlook for 1922 is somewhat better, but the most optimistic manufacturers do not expect the business for the new year to approximate the record year of 1920. The industry as a whole should grow and probably will grow faster in the next decade than any other lead-consuming industry, and before long it is possible that in prosperous times it will consume as much lead as the paint industry.

Many lead-incased cable factories were running full time in 1921, although the probable lead consumption was about 75 per cent. of normal. Lighter cables and possibly thinner sheathing were partly responsible for the reduction, and some important factories were not running full time. Business in 1922 is expected to be on about the same scale, although, as a matter of fact, the diminishing industrial loads have

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undoubtedly enabled the public-service corporations in the big cities to get through the short days of winter on a minimum of cable, and a resumption of business might create a big demand for this grade of cable. With the growth of the telephone and the increase of underground power conductors, the cable industry should always maintain its important position with respect to the lead industry.

Lead pipe, traps, and other blue-lead products used in the building trades were in fair demand during the first half of 1921, and for the last six months of the year business was even better. The industrial demand for this class of material has been poor. For the whole year the lead presses probably turned out about 80 per cent. of the normal tonnage. A large amount of building work has been planned. In certain districts the mortgage-loan market has greatly improved, and if early readjustment of labor costs occurs in the large cities, a good business may be confidently expected.

The demand for sporting ammunition, in common with the demand for paint, is usually expected to be good during hard times. The last year has proved an exception to this rule. The demand from the Southern States was particularly poor, the consumption of lead by this industry being between 50 and 60 per cent. of normal. There is nothing in the present situation to indicate a great increase in activity during 1922.

With the curtailment in general industrial business, the demand for bearing metals of all kinds has fallen off greatly and certainly may not be expected to be worse in 1922.

There was a small demand for sheet lead throughout the year; probably less than 30 per cent. of the normal production was marketed. Added to the poor industrial situation, the low price of cotton adversely affected the demand for this commodity. With the higher price of cotton, the growers will buy fertilizers, and the chemical companies should come into the market for some sheet lead before the summer of 1922. Activity of the lead mills, however, will depend on general business conditions.

The redeeming feature of the foil business in the last year has been the buying by the cigarette manufacturers. Though the demand for foil for other purposes fell off greatly, the entire industry operated at from 60 to 75 per cent. of capacity. This industry in a normal year is estimated to consume about 25,000 tons of lead. The demand for foil is affected by the price, and with the present low cost of lead the industry should experience a decided improvement. Should the custom of wrapping chewing-gum in foil again be adopted by the prominent makers, the outlook would be bright. The consumption of type-metals runs about the same from year to year. The demand for solder, caulking

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lead, rubber, glass and oil oxides and counterweights for locomotive driving wheels has been small owing to the general business depression. Though each of the above-mentioned uses consumes a relatively small amount of lead, in the aggregate at least 50,000 tons in normal times is used for these purposes.

The visible stocks of lead at no time during the last year became unwieldy. On the other hand, they are at this time decidedly unbalanced. The stocks of desilverized lead today are small, probably smaller than the average stocks before the war. Missouri lead, on the other hand, is held in fairly large quantities. The activity in white lead, which has saved the lead-mining industry from an almost complete shut-down, has placed a premium on lead of a corroding quality.

In August, the freight-rates from the Rocky Mountain states to North Atlantic ports were greatly reduced to meet the rail and water competition via the Panama Canal. There was no corresponding reduction in all-rail rates to intermediate points from the West or from the Mississippi Valley to Boston, New York, Philadelphia, or Baltimore. The large imports through the ports of New York and Philadelphia that began to arrive in April, and the August freight reduction from Rocky Mountain points to the seaboard, had the effect of drawing the St. Louis and New York markets close together, and thus denying to Missouri lead its usual outlet in the East. As before stated, the sheet-lead and battery industries, both large users of Missouri lead, were far below normal. Manufacturers of foil, cable, caulking lead, lead pipe, babbitt, and other lead alloys, situated in the East, who in the past had used some Missouri lead, used desilverized almost exclusively. The Spanish lead brought to Atlantic ports was sold largely to Eastern manufacturers. The combination of these circumstances brought about the conditions responsible for the accumulation of stocks of Missouri lead and the comparative scarcity of desilverized lead. Invisible stocks are low, as manufacturers in general have been following a hand-to-mouth policy of purchasing.

Prices.—The average quoted price of lead for prompt delivery at New York for the year was a little under 4.7 cts. per lb., as compared with an average selling price of 8.0 cts. in 1920. At the beginning of 1921 the price was 4.69 cts., but it rose to 5.375 cts. in the last half of January, and then by the first of March had dropped to 4 cts. flat. A recovery to 5.3 cts. took place early in May, after which the price came down to 4.4 cts. in the latter part of June. After holding for July and August at about 4.5 cts., the price gained 2 tenths of a cent by September, holding at about 4.75 cts. until the close of the year.

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AVERAGE MONTHLY PRICE OF LEAD PER POUND IN NEW YORK (a)

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	Cts.	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*
1907..	6.000	6.000	6.000	6.000	6.000	5.760	5.288	5.250	4.813	4.750	4.376	3.658	5.325
1908..	3.691	3.725	3.838	3.993	4.253	4.466	4.477	4.580	4.515	4.351	4.330	4.213	4.200
1909..	4.175	4.018	3.986	4.168	4.287	4.350	4.321	4.363	4.342	4.341	4.370	4.560	4.273
1910..	4.700	4.613	4.459	4.376	4.315	4.343	4.404	4.400	4.400	4.400	4.442	4.500	4.446
1911..	4.483	4.440	4.394	4.412	4.373	4.435	4.499	4.500	4.485	4.265	4.298	4.450	4.426
1912..	4.435	4.026	4.073	4.200	4.194	4.392	4.720	4.569	5.048	5.071	4.615	4.303	4.471
1913..	4.321	4.325	4.327	4.381	4.342	4.325	4.353	4.624	4.698	4.402	4.293	4.047	4.370
1914..	4.111	4.048	3.970	3.810	3.900	3.900	3.891	3.875	3.828	3.528	3.683	3.800	3.862
1915..	3.729	3.827	4.053	4.221	4.274	5.932	5.659	4.656	4.610	4.600	5.155	5.355	4.673
1916..	5.921	6.246	7.136	7.630	7.463	6.936	6.352	6.244	6.810	7.000	7.042	7.513	6.858
1917..	7.626	8.636	9.199	9.288	10.207	11.171	10.710	10.594	8.680	6.710	6.249	6.374	8.787
1918..	6.782	6.973	7.201	6.772	6.818	7.611	8.033	8.050	8.050	8.050	8.050	6.564	7.413
1919..	5.432	5.057	5.226	4.982	5.018	5.340	5.626	5.798	6.108	6.487	6.808	7.231	5.759
1920..	8.561	8.814	9.145	8.902	8.576	8.323	8.338	8.687	8.177	7.070	6.159	4.727	7.957
1921..	4.821	4.373	4.084	4.356	4.952	4.485	4.410	4.382	4.600	4.690	4.683	4.700	4.545

(a) From *Eng. Min. Jour.*

AVERAGE MONTHLY PRICE OF LEAD PER 2240 LB. AT LONDON (a)
(In pounds sterling)

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1907....	19.828	19.531	19.703	19.975	19.688	20.188	20.350	19.063	19.775	18.531	17.281	14.500	19.034
1908....	14.469	14.250	13.975	13.469	12.938	12.600	13.000	13.375	13.125	13.375	13.538	13.156	13.439
1909....	13.113	13.313	13.438	13.297	13.225	13.031	12.563	12.475	12.781	13.175	13.047	13.125	13.042
1910....	13.650	13.328	13.063	12.641	12.550	12.688	12.531	12.513	12.582	13.091	13.217	13.197	12.920
1911....	13.009	13.043	13.122	12.889	12.984	13.260	13.530	14.260	14.744	15.332	15.821	15.648	13.970
1912....	15.597	15.738	15.997	16.331	16.509	17.588	18.544	19.655	22.292	20.630	18.193	18.069	17.929
1913....	17.114	16.550	15.977	17.597	18.923	20.226	20.038	20.406	20.648	20.302	19.934	17.798	18.743
1914....	19.665	19.606	19.651	18.225	18.503	19.411	19.051	(b)	(b)	(b)	18.500	19.097	.....
1915....	18.606	19.122	21.883	21.094	20.347	25.170	24.611	21.946	23.151	23.994	26.278	28.807	22.917
1916....	31.167	31.988	34.440	34.368	32.967	31.011	28.137	29.734	30.786	30.716	30.500	30.500	31.359
1917....	30.500	30.500	30.500	30.500	30.500	30.500	30.500	30.500	30.500	30.500	30.500	30.500	30.500
1918....	29.00	29.00	29.00	29.00	29.00	29.00	29.00	29.00	29.00	29.00	31.20	40.00	30.100
1919....	37.227	28.625	27.952	24.888	23.852	22.544	23.457	24.750	25.330	28.473	34.731	41.202	28.590
1920....	47.095	50.256	46.054	39.225	38.488	34.330	34.960	36.304	35.452	35.238	32.489	24.089	37.832
1921....	23.387	20.650	18.911	20.589	23.399	22.563	23.399	23.489	23.148	23.679	24.483	25.322	22.752

(a) *Eng. Min. Jour.* (b) London exchange closed.

Foreign Market.—Demand for lead in Europe was strong during the latter part of the year. Ordinarily this demand is partly satisfied by the local production of various European countries, such as Germany, Poland, Spain, and France, plus importations from Australia. However, conditions in all of these countries are unsettled—if not politically, then industrially—affecting the production of each.

Germany is duplicating her activity in the copper market by her eagerness to absorb lead for manufacturing purposes. This is not strange when one considers the great necessity for the intense development of German export trade, and consequently of German manufacturers, to pay a large reparations bill. Germany, so long as she has a heavy indemnity to pay, should be a splendid market for raw materials, mineral, agricultural, and vegetable. Spanish lead and Mexican have been moving freely into Germany. There is a disposition to consider the fluctuations of mark exchange a deterrent to trade. However, Germany's activities in the copper markets and the unfulfilled predictions that

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exchange would adversely affect them, would indicate that exchange variations will have little to do with her ability to buy lead whenever necessary.[1]

Imports and Exports.—The imports of lead in ore were about 7000 tons, furnished chiefly by Canada, Mexico, and South America, and those of lead in bullion were about 41,000 tons, almost wholly from Mexico, as compared with a total of 62,796 tons in 1920. The lead content of lead ore in bonded warehouses on Nov. 30 was 7648 tons and of base bullion 16,207 tons, as against 16,462 and 34,758 tons respectively in 1920. Part of this lead, however, may have been smelted or refined but not shipped and thus may be included in smelter stocks.

The exports of lead of foreign origin were about 33,000 tons and of lead of domestic origin about 700 tons, as compared with 23,538 tons and 2730 tons, respectively, in 1920, an increase of about 7000 tons in the total exports. The imports of refined pig lead, which for the years 1916 to 1919 inclusive had been a little over 5000 tons a year and which had jumped in 1920 to 35,719 tons, maintained that high level in 1921, being about 32,000 tons. These heavy importations were the result of the relations of the New York and European prices and the rates of exchange.

IMPORTS OF LEAD, BY CLASSES, IN POUNDS

Year.	Lead in Ore (Lead Content).	Base Bullion.		Pigs, Bars, Sheets, and Old.	Total Lead Content.
		Gross Weight.	Lead Content.		
1912	19,577,499	152,420,624	146,999,168	544,925	167,121,592
1913	19,883,313	96,908,170	94,327,654	82,999	114,293,966
1914	23,649,637	33,444,503	32,730,320	296,846	56,676,803
1915	18,185,140	86,247,995	83,986,988	819,282	102,991,410
1916	35,086,100	24,943,660	24,262,435	11,310,817	70,659,352
1917	41,292,876	107,279,997	103,664,970	11,585,974	156,543,820
1918	37,070,340	155,810,003	149,663,889	10,480,531	197,214,760
1919	19,573,856	115,317,160	112,024,518	10,214,753	141,885,718
1920	29,488,816	101,476,550	96,103,603	71,457,108	197,029,527
1921	14,234,039	77,882,834	71,733,828	62,602,534	148,570,401

IMPORTS OF LEAD, IN ORE, BASE BULLION, AND REFINED, BY COUNTRIES, IN POUNDS (a)

Country from Which Imported.	1915.	1916.	1917.	1918.	1919.	1920.	1921.
United Kingdom.	185,236	261,406	2,689,992	56,710	.....	.....	.....
Germany	.....	.....	.....	.....	.....	.....	.....
Other European countries.	32,537	314,353	255,907	5,800	.....	.....	.....
British North America .	2,303,170	12,606,216	11,738,379	28,255,878	10,327,531	7,832,583	8,098,027
Mexico	94,247,384	48,395,670	135,782,759	162,259,199	115,436,528	105,028,017	74,953,799
South America	5,420,567	6,235,758	4,556,460	1,962,124	4,635,514	1,961,287	765,059
Other countries	802,516	2,845,949	5,520,323	4,705,049	1,198,801	10,770,532	2,150,982
Total imports.	102,991,410	70,659,352	156,543,820	197,214,760	131,598,374	125,592,419	85,967,867

(a) Bureau of Foreign and Domestic Commerce.

[1] Market editorial, *Eng. Min. Jour.*, Dec. 24, 1921.

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PIG LEAD EXPORTED FROM THE UNITED STATES (*a*)
(In pounds)

Destination.	1919.		1920.		1921.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Denmark	2,883,031	$227,778	851,200	$53,197	.....	.....
France	6,656,171	452,719	3,061,393	155,892	1,680,749	$78,993
Italy	.....	.....	.....	.....	.....	.....
Netherlands	1,724,949	95,721	3,763,441	311,493	.....	.....
Russia in Europe	4,000	280	.....	.....	.....	.....
Sweden	951,357	60,482	1,176,000	99,280	.....	.....
United Kingdom	46,404,068	2,851,214	5,382,207	397,502	25,851,837	1,229,126
Canada	4,147,181	242,987	3,443,536	223,945	418,410	25,811
Argentina	6,237,203	312,766	2,600,658	178,260	612,074	26,846
Brazil	3,743,199	268,315	4,936,127	376,919	1,684,179	68,466
China	1,273,194	66,791	344,897	32,263	16,786	772
Japan	23,687,710	1,077,394	7,952,080	622,688	8,344,051	341,361
Russia in Asia	5,100	425	.....	.....	.....	.....
Other countries	4,319,451	294,175	6,621,213	499,147	14,064,916	667,251
Total	102,036,614	$5,951,047	39,132,752	$2,950,586	52,673,002	$2,438,626
Total from domestic ore	21,019,605	$1,471,256	5,459,713	$462,223	3,247,294	$177,926
Total from foreign ore	81,016,588	4,479,723	33,663,553	2,486,576	49,425,708	2,260,700

(*a*) Bureau of Foreign and Domestic Commerce.

Secondary Lead

The production of secondary lead has increased steadily from year to year. In 1912, the U. S. Geological Survey estimated a production of 67,168 short tons. In 1919 it had reached the large amount of 125,000 tons, and in 1921 was almost as large. To this should be added the tonnage of shrapnel balls imported under the classification of type-metal and paying a 15-per cent. *ad valorem* duty. About 16,000 tons of this material was imported in 1921.

SECONDARY LEAD RECOVERED (*a*)

	1920. Short Tons.	1921. Short Tons.
Secondary lead recovered by smelters that treat mainly ores	12,787	.....
Secondary lead recovered by plants that treat only scrap and drosses	43,563	.....
	56,350	47,510
Secondary lead recovered in remelted alloys:		
Lead content of antimonial lead scrap treated at regular lead smelters	2,687	.....
Lead content of drosses and scrap alloys treated at secondary smelters	65,613	.....
Total lead in alloys	68,300	58,830
Total secondary lead recovered	124,650	106,340

(*a*) U. S. Geol. Surv.

Lead Pigments

The accompanying table shows the quantity and value of lead pigments of domestic manufacture sold in the United States, according to figures compiled by the United States Geological Survey.

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PRODUCTION OF LEAD PIGMENTS IN THE UNITED STATES

Year.	Red Lead.		White Lead. (a)		Litharge.		Orange Mineral.	
	Short Tons.	Value.	Short Tons.	Value.	Short Tons.	Value.	Short Tons.	Value.
1906...	13,693	$1,874,448	123,640	$15,234,990	13,816	$1,890,050	2,927	$421,488
1907...	13,370	1,778,717	111,409	12,254,297	14,769	1,624,553	815	123,917
1908...	11,358	1,156,282	116,628	10,515,315	12,254	1,231,206	393	43,157
1909...	15,800	1,438,197	131,643	12,652,638	13,391	1,266,903	530	68,003
1910 (b)	16,116	1,482,672	134,276	13,024,762	13,659	1,283,940	541	70,325
1911 (b)	19,594	2,345,520	132,612	17,393,241	25,190	2,733,196	766	119,370
1912 (b)	21,120	2,571,702	146,833	18,683,461	29,111	3,194,194	545	88,240
1913 (b)	17,635	2,127,976	142,626	18,112,219	23,093	2,524,707	434	71,625
1914 (b)	18,697	2,151,054	159,474	19,943,239	27,345	2,856,092	426	70,019
1915 (b)	19,435	2,397,900	156,101	19,393,691	26,118	2,822,415	.....	.....
1916 (b)	23,035	3,933,566	128,979	21,274,480	37,739	5,853,543	(c)	(c)
1917 (b)	25,478	5,525,018	115,200	22,529,831	44,102	8,611,074	(c)	(c)
1918 (b)	30,069	5,928,597	102,888	20,766,848	48,874	8,825,724	(c)	(c)
1919 (b)	32,362	5,314,255	139,090	26,425,022	46,739	6,431,801	(c)	(c)
1920 (b)	34,431	7,523,089	145,695	32,337,898	62,329	12,386,185	(c)	(c)
1921 (b)	21,805	3,414,452	170,283	31,260,563	41,909	5,735,824	381	91,887

(a) The output of "sublimed white lead," a mixed sulphate and oxide of lead, is not included. (b) U. S. Geol. Surv. (c) Orange mineral included in red lead.

IMPORTS OF LEAD PIGMENTS INTO THE UNITED STATES

Year.	Red Lead.		White Lead.		Litharge.		Orange Mineral.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1906.....	1,093,619	$50,741	647,636	$41,233	87,230	$3,737	770,342	$42,519
1907.....	679,171	35,959	584,309	37,482	90,475	4,386	615,015	37,799
1908.....	645,073	28,155	540,311	30,451	96,184	3,327	485,407	26,645
1909.....	760,179	30,428	694,599	39,963	90,655	3,740	496,231	27,562
1910.....	822,289	32,750	686,052	38,919	48,693	2,252	600,461	32,199
1911.....	1,163,533	46,170	741,071	46,213	24,662	1,196	504,734	28,515
1912.....	757,908	33,854	687,705	46,494	32,443	1,550	334,551	20,914
1913.....	99,832	4,903	672,109	45,266	34,023	1,750	330,525	22,205
1914.....	13,554	2,907	596,567	40,213	33,651	1,805	240,388	16,388
1915.....	1,968	142	239,187	24,608	20,650	1,422	171,572	14,061
1916.....	20,467	5,302	88,617	8,050	1,320	150	70,934	8,781
1917.....	50	13	20,238	1,965	*Nil.*	*Nil.*	33,294	4,892
1918	5	1	158	131	100	12	*Nil.*	*Nil.*
1919.....	7,199	1,136	21,213	2,490	*Nil.*	*Nil.*	39,781	5,081
1920.....	23,076	1,789	159,977	19,449	21,002	2,647	52,094	5,352
1921.....	12,236	689	124,176	12,598	100	7	77,937	7,830

After a long discussion the White Lead Commission at Geneva, reversing the decision of the Committee of the League of Nations, has under the lead of France agreed on the text of a new international agreement which prohibits the use of white lead in the interior of buildings. Its use elsewhere remains authorized, but will be submitted to precise regulations.

The agreement will come into force in six years. It will be sent to the Drafting Committee and will then come again before the Conference for final ratification, when a majority of two thirds of the votes will be required for acceptance. The text follows:

INTERNATIONAL CONVENTION ON THE EMPLOYMENT OF WHITE LEAD

ART. 1.—Each member of the International Labor Organization ratifying the present Convention undertakes to prohibit, with the exceptions provided for in

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Article 2, the use of white lead and sulphate of lead and of all products containing these pigments in the internal painting of buildings, except where the use of white lead or sulphate of lead or products containing these pigments is considered necessary for railway stations or industrial establishments by the competent authority, after consultation with the employers' and workers' organizations concerned.

It shall, nevertheless, be permissible to use white pigments containing a maximum of 2 per cent. of lead expressed in terms of metallic lead.

ART. 2.—The provisions of Article 1 shall not apply to artistic painting or fine lining. Each Government shall define the limits of such forms of painting, and shall regulate the use of white lead, sulphate of lead, and all products containing these pigments for these purposes, in conformity with the provisions of the succeeding Articles of this Convention.

ART. 3.—The employment of males under 18 years of age, and of all females, shall be prohibited in any industrial work involving the use of white lead or sulphate of lead, or other products containing these pigments not prohibited by Articles 1 and 2.

ART. 4.—The prohibitions prescribed in Articles 1 and 3 shall come into force six years from the date of closure of the Third Session of the International Labor Conference.

ART. 5.—Each member of the International Labor Organization ratifying the present Convention undertakes to regulate the use of white lead, sulphate of lead, and all products containing these pigments, in operations for which its use is not prohibited, on the following principles:

1. (*a*) White lead, sulphate of lead, and products containing these pigments, shall not be used in painting operations except in the form of paste or paint ready for use. (*b*) Measures shall be taken in order to prevent danger arising in the application of paint in the form of spray. (*c*) Measures shall be taken, wherever practicable, to prevent danger arising from dust caused by dry-rubbing down and scraping.

2. (*a*) Adequate facilities shall be provided to enable working painters to wash during and on cessation of work. (*b*) Overalls shall be worn by working painters during the whole of the working period. (*c*) Suitable arrangements shall be made to prevent clothing put off during working hours being soiled by painting material.

3. (*a*) Cases of lead-poisoning and of suspected lead-poisoning shall be notified, and shall be subsequently verified by a medical man appointed by the competent authority. (*b*) The competent authority may require, when necessary, a medical examination of workers.

4. Instruction with regard to the special hygienic precautions to be taken in the painting trade shall be distributed to working painters.

ART. 6.—The competent authority shall take such steps as it considers necessary to ensure the observance of the regulations prescribed by virtue of the foregoing Articles, after consultation with the employers' and workers' organizations concerned.

ART. 7.—Statistics with regard to lead-poisoning among painters shall be obtained: (*a*) As to morbidity—by notification and certification of all cases of lead-poisoning. (*b*) As to mortality—by a method approved by the official statistical authority in each country.

An inquiry as to whether the use of white lead involves a risk to health—a question of concern to all engaged or interested in lead mining—was recently held by the New South Wales Board of Trade.[1] The question considered was whether white lead as used in the painting indus-

[1] *Queens. Govt. Min. Jour.*, Dec. 15, 1921.

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try, was so injurious to painters and other workmen in the industry that it was expedient or necessary to regulate, restrict, or prohibit its use in paints or pigments.

The board found that it could not recommend the restriction of the use of white lead in paints or pigments, as there were no means of measuring the degree of restriction which might prevent the evils complained of.

"Lead, as used in the painting industry," the report states, "is a substantial cause of injury and death to painters. As a cause of death, lead is more effective in this industry than in any other occupation, but its toll of deaths does not, by any means, indicate its deleterious influence or destructive power.

"Nine per cent. of the 3969 persons included in the Broken Hill survey were found to show arterio-renal symptoms which might have been due to lead absorbed as the result of exposure mainly to the dust of sulphide and oxide ores. The vital statistics show that for every nineteen miners who die from lead poisoning in a series of years there are twenty-two painters who die from the same cause.

"Lead-poisoning being a preventable disease, as the medical witnesses and other authorities available to the board all agree, it would indeed be a desperate situation if the only means of prevention were the abolition of the use of lead.

"Care on the part of employees themselves is a necessary condition of the prevention of lead-poisoning. The employee can avoid the unnecessary raising of dust, the splashing of lead material to a great extent, and eating or smoking with unwashed hands. Personal hygiene is a matter of supreme importance with those who are exposed to lead risks. The surface of the body, the nails, the mouth, and the teeth ought to be kept clean by the lead worker if he desires to preserve normal health. Cleanliness in clothing and working overalls, a reasonably normal dietary, and the avoidance of intemperance all help to strengthen the defences against lead-poisoning. Regulation of the use of white lead in the painting industry is immediately necessary, both in the interests of painters and the community."

The board recommended that the following conditions should be embodied in local legislation: Locally applied exhaust ventilation, so as to remove dust and fumes at the point of origin; cleanliness of tools and workrooms; notification to Government authorities of all cases of lead-poisoning and compensation therefor; periodic medical examination of the persons employed in such processes; provision of sufficient and suitable cloakroom, washing, and mess-room accommodation, and of special protective clothing; prohibition of bringing food or drink into workrooms.

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PRIMARY LEAD SMELTED OR REFINED IN THE UNITED STATES (a)
(Short tons. Apportioned according to source of ore)

	1913.	1914.	1915.	1916.	1917.	1918.	1919.	1920.	1921
Domestic Ore:									
Alaska	6	.....	358	659	884	531	645	591	773
Arizona	4,901	5,602	6,953	15,328	7,456	6,195	5,407	5,987	3,313
Arkansas	.....	52	51	170	300	14	.....	.....	.....
California	3,294	3,698	5,606	3,633	11,471	6,228	2,004	2,260	614
Colorado	42,840	41,198	32,352	33,046	29,327	29,395	18,867	17,752	12,104
Idaho	137,802	177,827	160,680	170,059	174,045	142,640	89,091	117,191	99,707
Illinois	619	427	910	670	867	1,010	977	948	271
Iowa	.....	34	.....	.....	.....	.....	.....	.....	.....
Kansas	1,504	1,043	1,320	1,737	2,663	5,023	7,951	8,421	10,939
Kentucky	16	16	95	37	21	109	83	114	41
Missouri	152,430	194,275	195,634	218,253	218,197	187,743	150,341	171,999	151,028
Montana	3,256	4,386	4,853	4,961	5,933	17,586	17,513	13,231	11,565
Nevada	6,142	5,996	7,664	11,858	12,334	8,726	5,958	8,650	3,553
New Mexico	1,821	741	2,157	3,290	3,428	5,140	1,418	1,123	884
New York	.....	.....	.....	.....	.....	49	.....	.....	.....
North Carolina	10	.....	.....	.....	.....	.....	.....	.....	.....
Oklahoma	3,214	3,916	4,346	10,969	19,646	58,755	49,984	68,494	46,902
Oregon	37	17	11	9	.....	6	.....	.....	.....
South Dakota	7	2	5	12	34	28	18	6	2
Tennessee	.....	.....	8	.....	.....	843	2,371	2,705	.....
Texas	108	89	111	26	58	30	8	1	1
Utah	71,069	88,976	106,105	111,789	82,081	76,169	65,102	64,006	51,872
Virginia	878	143	457	740	147	59	.....	.....	.....
Washington	9	2	11	217	929	906	1,090	2,460	325
Wisconsin	2,639	1,818	2,632	3,121	2,930	4,275	3,975	3,841	1,079
Undistributed	63	99	131	159	145	59	119	201	101
Zinc residues	3,765	4,125	4,567	5,478	6,489	5,359	4,887	4,366	713
Total from domestic ore	436,430	534,982	537,012	596,221	579,385	556,878	427,825	494,347	395,287
Foreign Ore:									
Africa	5,976	2,942	.....	328	1,738	1,519	644	1,171	.....
Australia	.....	.....	.....	.....	.....	282	69	450	.....
Canada	16	2	1,174	1,231	1,100	7,550	1,895	1,186	2,877
Central America	.....	.....	1	7	.....	.....	12	22	6
Mexico	4,512	2,386	5,437	1,917	7,607	4,798	2,261	2,729	1,912
South America	2,617	1,821	2,829	2,366	1,533	1,101	2,537	2,747	2,235
Other foreign	102	488	140	236	3,894	84	238	109	90
Foreign Base Bullion:									
Canada	.....	.....	.....	1,072	6,750	8,108	567	1,919	1,599
Mexico	37,359	21,689	33,173	11,598	39,508	76,809	49,564	42,421	41,648
South America	.....	.....	275	151	189	39	.....	54	.....
Total from foreign ore and base bullion	50,582	29,328	43,029	18,906	62,319	100,290	57,787	52,808	50,367
Grand total, derived from all sources	487,012	563,810	580,041	615,127	641,704	657,168	485,612	547,155	445,654

(a) C. E. Siebenthal, U. S. Geol. Surv.

Lead Mining in the United States

The following reports, except where otherwise noted, are from the U. S. Geological Survey.

Alaska.—The lead production of Alaska in 1921 was valued at $46,000 as compared with a production valued at $140,000 in 1920.

The Kantishna district, just north of Mount McKinley, has long been the scene of a little placer mining, as well as of small developments of gold- and silver-bearing lodes. Two years ago a galena deposit was opened up, and since then about 1000 tons of ore has been shipped.

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The district is about 50 to 70 miles west of the Alaska Railroad, but it has no road connection with that line, and the ore had to be transported by horse sleds to Kantishna River and thence by small steamers to the Tanana. This method of transportation was so expensive that only the richest ore would stand shipment. Therefore the galena ore was hand picked, the grade of shipments being thus brought to an average of about 182 oz. of silver and $3.20 in gold to the ton, in addition to the lead and some copper. The lode from which this ore came and others at near-by localities are at or near Eureka Creek. The deposits lie in well-defined fissures traversing schistose rocks and are associated with granitic intrusives. Some of the orebodies are 8 to 15 ft. wide, but the rich galena is in shoots from 6 in. to 2½ ft. in width. Gold-bearing quartz veins of similar type are also found in this part of the district, as well as some deposits of antimony (stibnite). The few openings made indicate that the lodes are fairly persistent along the strike.

In 1921 sulphide-bearing lodes were discovered in the foothills of the Alaska Range 20 miles southeast of Eureka Creek, in the Kantishna district. These deposits were found by O. M. Grant and F. B. Jiles, both experienced prospectors, who staked 22 claims. They lie some 14 miles from timber, but lignite beds are close at hand. They are readily accessible to pack-horses. The construction of about 50 miles of wagon road would connect the locality with the Alaska Railroad at Riley Creek. Granodiorite is the prevailing country rock of the region and is found both in large areas and as dikes. Banded and massive quartzites with some limestones and slate cut by granodiorite dikes constitute the formations in which the ores have been found. The sedimentary beds are much deformed and trend a little north of west.

The orebodies are distributed through a zone that trends a little north of east and thus apparently cuts across the bedding of the sediments. It has been traced about 2 miles and is reported to be longer. As determined by present discoveries, its width is from ¼ to 1 mile wide. This zone is characterized by an abundance of sulphide minerals, concentrated in more or less well-defined orebodies.

Arizona.—The mine production of lead in Arizona decreased from 14,599,765 lb. in 1920 to about 6,541,433 lb. in 1921. The value of the output decreased from $1,167,981 to about $294,364. No shipments of lead ore or concentrate were made from the Shattuck mine, which was the largest producer of lead in 1920. Much silver-lead ore, however, was shipped from the Copper Queen mine, especially from September to the close of the year, and the Bunker Hill Co., at Tombstone, shipped much lead ore as well as silver ore to El Paso, Tex.

California.—California produced 1,124,276 lb. of lead in 1921, com-

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pared with 4,813,510 lb. in 1920. The market for lead, copper, and zinc ores during the past year was so poor that very few mines operated.

Colorado.—C. W. Henderson reports that Colorado produced only 20,600,000 lb. of lead in 1921. This is a decrease of 24,783,025 lb. from the 1920 production.

The Leadville and Durango lead-copper smelters did not operate all their furnaces. The Pueblo lead-copper smelter continued operations until the flood of June 3, when the plant was closed. The River Smelting and Refining Co.'s matting and volatilization plant for the treatment of zinc-lead-copper ores at Florence was idle until December, when it reopened on stock ores.

Leadville, one of the oldest and most persistently producing districts in Colorado, which mines many kinds of ore and shows great fluctuation in production according to changes in the prices of metal, was affected seriously by the low prices for lead and zinc. The Yak mine continued development and made shipments of silver-iron ore. It is proposed to equip the old Yak mill building with new machinery, including that for flotation to treat the lead-zinc-iron sulphide ores of the Yak properties. The A. V. smelter operated three furnaces throughout the year.

Lead production, by counties, was as follows, in pounds:

County.	1920.	1921.
Boulder	226,825	170,000
Chaffee	399,123	325,000
Clear Creek	3,284,612	1,264,000
Custer	171,560	97,000
Dolores	757,052	19,000
Eagle	292,528	10,300
Gilpin	438,289	80,000
Gunnison	852,080	9,500
Hinsdale	79,690	66,000
Lake	9,543,758	3,202,000
La Plata	949	2,500
Mineral	531,536	153,300
Ouray	1,302,681	1,124,400
Park	1,085,665	679,000
Pitkin	4,490,648	2,300,000
Grand	528	.....
Saguache	160,140	273,000
San Juan	14,741,907	2,191,000
San Miguel	7,550,027	8,258,000
Summit	448,217	376,000
Teller	25,210	.....
Total	45,383,025	20,600,000

Idaho.[1]—The production of lead decreased from 249,609,976 lb. in 1920 to 210,100,194 lb. in 1921, with a value of $9,559,559. The value of the 1921 output based on 1920 prices would have been $16,808,016, a difference, or loss, of $7,248,457, caused by the reduced price of lead, which averaged 8 cts. per lb. in 1920 and 4.55 cts. in 1921.

[1] Annual Report, Idaho Inspector of Mines.

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Following is the lead production of Idaho, by counties:

	Pounds.	
	1920.	1921.
Blaine	2,149,593	4,870,692
Boise	1,650	.....
Bonner	2,307	11,452
Boundary	3,429,540	1,818
Butte	144	67,812
Camas	6,319	.....
Custer	1,932,088	803,092
Gem	879	.....
Lemhi	5,876,375	2,164,670
Owyhee	780	.....
Shoshone	236,310,301	202,175,364

The lead production of Idaho since 1903 is as follows:

	Pounds.	Value.
1903	213,143,618	$9,135,335
1904	233,096,375	10,197,966
1905	259,812,428	12,211,184
1906	255,014,446	14,535,823
1907	233,823,854	12,392,664
1908	206,827,816	8,686,768
1909	215,986,285	9,287,410
1910	228,258,839	10,043,389
1911	272,556,525	12,265,044
1912	284,185,657	12,788,355
1913	317,871,945	13,986,366
1914	348,526,069	13,592,517
1915	345,999,466	16,261,975
1916	375,081,781	25,880,643
1917	393,559,521	33,846,119
1918	294,695,993	20,923,416
1919	182,341,898	9,664,121
1920	249,609,976	19,968,798
1921	210,100,194	9,559,558

The Bunker Hill and Morning mines were the largest producers of lead in 1921, and the Hecla mine increased its output. Other large producers were the Hercules, Tamarack & Custer, Caledonia, Independence (Blaine County), Sierra Nevada, Idaho Continental (Boundary County), and Pittsburg Idaho (Lemhi County). The mill of the Gold Hunter Mining & Smelting Co. was idle, but first-class lead ore rich in silver was shipped by lessees. The Coeur d'Alene district alone produced about 183,000,000 lb. of lead.

Joplin District.[1]—Lead concentrates were on $55 basis for 80 per cent. lead at the beginning of 1921, declining to $50 on the first and to $35 at the end of February, continuing to mid-March, when it advanced to $40 on the upward trend to $60 in the middle of May, then declining steadily to $40 by the end of June. The reaction following sent it as steadily upward to $60 at the end of September, dropping to $55 at the end of October and to $53.50 at the end of November, when it was advanced by renewed demand to $54, and closed the year at $58.

[1] Jesse A. Zook, *Eng. Min. Jour.*, Feb. 4, 1922.

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LEAD ORE PRICES IN THE JOPLIN DISTRICT
(Per ton of 2000 lb.)

	Past Years.		1921.	
	High.	Average.		
1908	$66.00	$54.66	January	$49.47
1909	60.50	54.56	February	47.02
1910	58.00	51.98	March	45.51
1911	64.00	56.76	April	44.98
1912	68.00	56.60	May	56.19
1913	58.00	52.52	June	48.17
1914	54.50	46.55	July	44.97
1915	80.00	55.08	August	49.61
1916	104.84	84.07	September	53.56
1917	135.50	98.00	October	59.65
1918	106.00	88.98	November	58.82
1919	89.00	66.20	December	56.99
1920	112.50	95.71		
1921	65.20	51.92	Year	$51.92

Montana.—The mine production of lead in Montana decreased from 31,253,916 lb. in 1920 to 20,366,917 lb. in 1921, and the value of the output decreased from $2,500,313 to about $916,511. Some of the largest producers of lead, such as the Butte & Superior, Anaconda, Snow Storm, and Angelica, were either idle or operated at reduced capacity in 1921. The Snow Storm mine, at Troy, resumed milling operations in November, and the new 750-ton mill of the Boston & Montana Co., at Wise River, Beaverhead County, made its first concentrates. The Neihart Consolidated at Neihart, Block P. near Monarch, Lukens Hazel at Libby, Evening Star at Elliston, and Greenback near Alder were especially active in producing silver-lead ore in 1921. The smelting plant of the American Smelting & Refining Co., at East Helena, was active in 1921 and shipped an increased quantity of lead bullion, which was made largely from ore shipped from mines in Idaho.

The Montana lead production, by counties, is given as follows, in pounds:

	1920.	1921.
Beaverhead	1,968,009	234,407
Broadwater	401,551	287,358
Cascade	3,127,148	1,498,387
Fergus	358	.....
Granite	76,033	421,102
Jefferson	3,414,357	817,266
Judith Basin	.....	1,715,151
Lewis and Clark	829,987	434,788
Lincoln	3,328,265	1,007,768
Madison	287,408	540,506
Mineral	43,848	18,226
Missoula	.....	9,488
Park	95,680	1,292
Powell	88,721	136,364
Sanders	.....	3,317
Silver Bow	17,590,182	13,241,497
Toole	2,369	.....
	31,253,916	20,366,917

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Nevada.—The mine output of lead decreased in quantity from 21,263,700 lb. in 1920 to about 7,188,768 lb. in 1921, and in value from $1,701,096 to about $323,495. The mines of the Yellowpine district, Clark County, were practically idle, and the Prince Consolidated mine at Pioche was active only three months. Most of the lead ore came from the Bristol Silver, Prince Consolidated, and Virginia Louise, at Pioche; the Eureka Holly, Eureka Croesus, and Richmond Eureka, at Eureka; the Leadville mine, near Gorlach; and the Spruce Monarch, south of Tobar. Mill operations were started at the Simon mine in Mineral County.

The first carload of lead concentrate from the Simon Silver-lead Mining Co.'s new mill, situated near Mina, Nev., was delivered to the U. S. S. smelter at Midvale, Utah, late in December.[1]

New Mexico.—The U. S. Geological Survey reports that New Mexico's lead production was 678,601 lb. in 1921. This compares with 2,869,525 lb. produced in 1920.

Utah.—The mine output of lead decreased from 140,838,113 lb. in 1920 to about 89,187,269 lb. in 1921. The value of the output decreased from $11,267,049 to about $4,013,427. As the average price of lead was about 4.50 cts. a lb., it was not profitable to ship lead ore unless it contained much silver. The largest producer of lead was the United States Mining Co., at Bingham, but the Utah Apex and Utah Consolidated mines were idle. The output from the Tintic, Park City, and Bingham districts was decidedly less. The closing of the lead smelter at International in July seriously affected shipments from Ophir, Park City, and Eureka.

The mines of the Tintic district produced about 32,543,000 lb. of lead. The shipments from the Park City region accounted for 16,425,000 lb. of lead. The lead smelters at Midvale and Murray were operated at a reduced rate during the year. At International the copper plant was idle and the lead plant was closed in July. In August the freight on bullion was reduced, and by December the smelters had disposed of surplus stocks and were merely shipping the current production.

The production of lead in Utah, by counties, is given as follows, in pounds:

	1920.	1921.
Beaver	2,808,314	1,271,131
Box Elder	18,130	7,306
Juab	27,902,353	27,186,059
Piute	859,753	1,597,626
Salt Lake	59,162,056	29,619,285
Summit	18,220,550	10,507,694
Tooele	10,272,259	2,538,512
Utah	14,083,144	9,267,537
Wasatch	7,511,554	7,183,528
Weber	.....	8,591
	140,838,113	89,187,269

[1] *Min. Sci. Press.*

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Washington.—The mine output of lead decreased from 5,787,247 lb. in 1920 to 143,553 lb., valued at $6460 in 1921. It was unprofitable to ship lead ore from the Electric Point and other mines near Northport, as the ore contains little or no silver.

LEAD PRODUCTION OF THE WORLD
(In metric tons)

Year.	Australia. (a)	Austria. (a)	Belgium. (a)	Burma. (a)	Canada. (a)	France. (a)	Germany. (a)	Greece. (a)	Hungary. (a)
1906	93,557	14,846	23,765	.....	24,580	25,614	150,741	12,308	1,925
1907	96,608	13,598	27,450	.....	21,660	24,800	164,079	13,814	1,468
1908	119,207	12,669	35,650	.....	19,593	26,112	164,079	15,892	1,544
1909	77,992	12,941	40,306	.....	23,295	26,927	167,920	14,948	1,590
1910	105,897	15,476	40,715	.....	14,967	20,226	159,851	16,710	2,077
1911	105,397	18,097	44,308	.....	10,791	23,635	161,287	14,234	1,583
1912	113,710	19,993	54,940	.....	16,226	31,080	192,618	14,498	1,605
1913	110,444	1,368	53,590	5,951	17,089	28,817	181,100	18,309	(e)1,790
1914	101,788	755	45,560	10,717	19,888	29,601	198,450	20,684	1,368
1915	102,721	.....	16,770	13,758	21,009	14,539	134,750	11,595	.....
1916	134,072	.....	15,560	14,011	18,823	24,276	106,807	9,424	.....
1917	144,950	783	22,745	17,233	14,776	21,235	86,228	1,422	.....
1918	163,368	.....	20,630	19,380	23,314	12,778	69,960	4,093	.....
1919	83,404	.....	4,225	19,396	19,880	10,928	51,480	3,841	.....
1920	(i) 6,935	(i)3,973	16,040	24,198	16,309	(i)12,000	(i)59,000	(i)4,857	.....
1921	(i)56,641	(i)4,000	21,000	33,721	30,457	(i)13,000	(i)72,000	(i)18,000	.....

Year.	Italy. (a)	Japan. (a)	Mexico. (a)	Rhodesia. (i)	Spain. (a)	Sweden. (a)	United Kingdom. (a)	United States.	Totals. (f)
1906....	21,268	4,305	(b)73,699	.....	185,470	753	29,675	323,567	986,980
1907....	22,978	3,067	(b)76,158	.....	(d) 185,800	813	35,730	322,854	1,011,397
1908....	26,003	2,910	(b)127,010	.....	188,062	277	32,816	284,858	1,057,205
1909....	22,133	3,429	(b)118,186	.....	179,993	166	30,878	329,690	1,056,326
1910....	14,495	3,907	(b)120,662	.....	190,523	355	30,799	353,186	1,093,043
1911....	16,684	4,160	(b)124,605	.....	189,810	1,134	28,327	368,301	1,108,880
1912....	21,450	3,613	(b)109,717	.....	232,612	1,073	27,728	376,947	1,212,252
1913....	21,674	3,777	(i)62,000	.....	198,829	1,235	18,462	396,034	1,142,264
1914....	20,464	4,563	(i)23,598	.....	143,524	1,396	19,684	485,011	1,127,051
1915....	21,812	4,764	(i)31,384	485	171,472	1,918	15,767	487,177	1,049,921
1916....	24,362	11,343	(i)19,966	1,264	147,407	2,076	12,775	540,892	1,083,058
1917....	16,237	15,807	(i)46,612	3,882	172,909	3,174	11,431	(g)527,729	1,107,153
1918....	18,332	10,769	(i)88,503	9,308	169,709	2,241	11,269	(g)504,614	1,128,268
1919....	16,530	5,771	(i)78,645	12,859	125,721	827	11,458	(g)412,704	857,660
1920....	15,947	(i)4,179	(i)85,209	14,835	175,195	863	11,136	(g)427,966	878,640
1921....	11,500	(i)6,780	60,513	18,577	(i)120,000	(i)750	(i)10,000	(g)369,136	846,075

(a) From official reports of countries unless otherwise denoted. (b) Exports. (d) U. S. imports. (e) Estimated. (f) The totals may be high on account of duplications which cannot be eliminated. (g) From *Eng. Min. Jour.* (h) Production of pig lead in Mexico. Lead smelted from Mexican ore in the United States is not included either under Mexico or the United States. (i) Am. Bur. Metal Stat.

Lead in Foreign Countries

Algeria.—The following statistics, relating to the production of the lead mines in all of Algeria during the year 1920, were published in *L'Information*, Nov. 16, 1921:

Province of Alger: Chabel-el-Kohol (Société de Chabet-et-Kohol), 562 metric tons of lead ore; Sakamody (Banque Atlas), 14 tons. Province of Constantine: Bou Thaleb, 599 tons of lead ore; Djebel Gustar (Compagnie du Djendii), 171 tons; Sidi Kambi (groupe constantinois), 828 tons; Mestoula, 6300 tons; Djebel Felten, 3234 tons; Nador (Vieille-Montagne), 4379 tons.

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Official statistics give the total exports of lead ore from Algeria in 1920 as 12,804 metric tons, which fell to 11,421 tons in 1921. Of the 1921 exports 8213 tons went to France.

Australia.—After well over two years' interruption of work, lead production at Port Pirie was resumed on Aug. 18, 1921, on a comparatively restricted scale. Misfortune has dogged the Broken Hill group for some time. In May, 1919, the great strike began which entailed the closing a couple of months later of the smelting plant, the stocks of concentrates having been used up. In November of the following year the strike ended, and the smelter resumed operations soon after, but in January of this year a disastrous fire occurred there, which forced a fresh suspension till Aug. 18, as stated. Prior to the war the smelter treated some 6000 tons of concentrates a week, but the reconstructed plant has a roasting capacity of only half this quantity, and with the present facilities the lead output cannot exceed about 65,000 to 70,000 tons a year. After supplying the needs of the Far Eastern market, probably 45,000 tons will be left for Europe, but much, of course, depends upon whether or not costs and selling prices are sufficiently favorable to permit of profitable operations. For production to be maintained even at the reduced rate, conditions must be more acceptable than they are to-day.[1]

Canada.[2]—Notwithstanding the general decline in prices during 1920 and 1921, the quantity of lead recovered by the Canadian smelters and contained in shipments exported showed a notable increase. Of the three producing provinces British Columbia made the most notable increase, while normal production was maintained by Ontario and Quebec. The price of lead on the Montreal market, which was 11 cts. per lb. in March, 1920, had, by December of the same year, fallen to 6.75 cts. per lb. During the calendar year 1921 the average price on the Montreal market in car lots was 5.742 cts.

The Dominion production from all sources amounted to 67,146,011 lb., which at the average Montreal price for the year was valued at $3,855,524. Compared with 1920, the production showed an increase of 86.75 per cent. in quantity above the 35,953,717 lb. produced in that year and 19.95 per cent. above the value recorded, namely, $3,214,262 (8.940 cts. per lb.). The lead production included the refined lead and pig lead produced in Canada from the treatment of domestic ores, together with the lead estimated as recovered from ores exported to the United States.

The 1921 production was composed of 59,023,488 lb. of refined lead produced at Trail; 3,309,793 lb. of pig lead from the lead smelters at Galetta, Ont., and the estimated quantity of 4,812,730 lb. recovered from

[1] *Metal Bull.*, Aug. 23, 1921.
[2] Prelim. Rept. Min. Prod. of Canada, 1921, Dominion Bur. of Statistics.

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exported ores. The lead ores exported amounted to 4835 tons, having a content of 5,360,000 lb., 90 per cent. of which was estimated as recovered. These exported ores were principally from the East and West Kootenays and the Yukon Territory, supplemented by small shipments from Notre Dame des Anges in Quebec. The total mine shipments of lead ores and concentrates were in the neighborhood of 304,000 tons containing approximately 67,139,300 lb. of lead.

The record of lead contents of lead ores and concentrates shipped and recoveries made from domestic and imported ores are shown below, together with a record of pig and refined lead produced.

	1918. Pounds.	1919. Pounds.	1920. Pounds.	1921. Pounds.
(1) Lead contents of ores and concentrates shipped from mines in Canada	46,843,602	32,147,989	33,802,270	67,139,303
(2) Production: Smelter recoveries from Canadian ores and recoverable lead in ore exported	51,398,002	43,827,699	33,985,974	67,146,011
(3) Total production of refined lead in Canada (including lead from imported ores)	31,571,112	34,330,920	28,720,030	57,640,000

So far as lead and zinc are concerned, the Trail smelter in British Columbia has broken all its records, and the smelter operated throughout the year, full blast. For the last six months every plant at Trail connected with either of those metals broke its own record month by month, incident to the improvements in treatment. There is another angle to this, it being obvious that large-scale operation is necessary if costs are to be at the minimum, which they must be in order to make operation reasonable. An example of this expansion of output is the test mill at Trail, built for the Sullivan ore, whose original capacity of 500 tons per day has now worked up to 1000 tons, which is probably not yet the limit. The lead and zinc ores are no longer shipped separately, but all the Sullivan ore goes by one route, being separated in the course of milling, the zinc plant producing lead concentrate as a by-product. The concentrator is recovering more lead as a high-grade lead concentrate, and more zinc as a high-grade zinc concentrate, so that a ton of Sullivan ore nowadays yields more pounds of refined metal than such a ton did formerly. This is a very moderate statement of the facts. Various processes have been devised and given a trial in the test mill, but flotation is the basis of the present satisfactory recoveries. Incidentally a certain old criticism of the Trail smelter must now be revised, for it can no longer be contended that the Sullivan ore is being financed at the expense of shipments from private mines, when there is no zinc ore from private shippers to mix with the Sullivan ore.[1]

[1] *Can. Min. Jour.*

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While the metallurgical staff at Trail has been winning its victories over the Sullivan complex ore, the mines department has further developed the property by putting through the raise from the "tunnel" below to the "hill" above, thus connecting the two mines by an air-way that in the course of time will be utilized for taking out the ore below the level of the upper workings. The "tunnel," which was driven to the ledge in 1920, is at present furnishing the bulk of the ore. The most modern methods are used in mining the ore, power scrapers being used to haul the broken-down ore into the raises, where it reaches the cars by way of chutes, or, where conditions are suitable, the cars are loaded by mechanical muckers.

China.—The Chuling mining works, which is operating a lead mine in Chemping district, recently made its first shipment of lead, according to Consul M. S. Myers at Swatow, China.[1] Smelting by native methods is carried on at the mine, the present capacity of the furnaces being three short tons per day. It is planned to double this furnace capacity at an early date. A high-grade soft lead, running between 99.97 and 99.98 per cent. pure, is produced. It is shipped in slabs weighing 140 catties (about 187 lb.) each. About 115 short tons has already been exported. A ready market for this product is found in South China.

France.—The production of argentiferous lead in France is very restricted, most of the mines being shut down. On the other hand, the development of the Soc. Albigeoise des Mines de Peyrelmare, in the Tarn district, is interesting. The Peyrelmare mine, which produced 1730 tons of argentiferous lead in 1912, and 1535 tons in 1913, almost maintained full output during the war, producing 19,468 tons of ore in 1917, 26,789 tons in 1918, 18,328 tons in 1919, and 19,028 tons in 1920. During 1919 and 1920, the Lieux-Lafenasse works, attached to the mine, delivered 644 tons and 735 tons respectively of soft lead, and 644 kilos and 1367 kilos of fine silver.[2]

Germany.—During 1920 Germany imported 17,306 tons of pig lead. The main sources of supply were as follows: United States, 3336 tons, Great Britain 3715 tons, Central America 2258 tons, Belgium 1303 tons, Holland 1320 tons, Italy 1251 tons, Denmark 804 tons, and Austria 640 tons. The exports were mainly to England (4086 tons) and totaled 8757 tons.

The German exports of lead pipes and sheets during 1920 were 5278 tons, of which Holland took 2561 tons and Finland 700 tons.

Great Britain.—Lead mining is of great antiquity in the British Isles, dating back to the time of the Roman occupation; and for many centuries

[1] *Comm. Rept.*, Dec. 19, 1921.
[2] *Metal Bull.*

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large quantities of lead ore were obtained from outcrops and shallow workings. Deeper mining, involving pumping, belongs to a comparatively late period, but was carried on vigorously during the last century.

Consequently, the more accessible and richer ore-shoots are now exhausted, and in general it is where natural difficulties (such, for instance, as the presence of more water than could be dealt with by the appliances in use) hindered exploitation that the richer orebodies have been preserved for the miners of to-day. A notable example of this is the Halkyn district of Flintshire, where the lodes in the mountain limestone are so heavily watered that they could not be mined to any considerable depth with ordinary pumping appliances. The driving of a drainage tunnel, which was completed about 1886, enabled them to be worked down to 200 ft. above sea-level. A new tunnel has been commenced and would, if continued as projected, unwater the mines down to sea-level, thus rendering a large quantity of valuable lead ore available for mining.

UNITED KINGDOM LEAD EXPORTS (*a*)
(In long tons)

	1919.		1920.		1921.	
	English.	Foreign.	English.	Foreign.	English.	Foreign.
January	1,042	.....	2,631	2,048	1,165	445
February	596	.....	2,707	2,904	1,331	551
March	1,252	.....	3,987	3,540	1,738	2,326
April	1,030	203	2,651	2,259	935	1,130
May	1,023	229	2,366	951	883	1,710
June	1,073	132	2,508	1,172	600	615
July	1,854	220	3,855	105	952	1,090
August	4,091	700	3,428	1,679	855	1,127
September	2,145	1,114	3,841	5,025	1,332	611
October	4,222	3,181	3,146	3,937	2,519	691
November	3,298	2,576	2,069	1,865	2,088	755
December	3,944	2,449	1,439	1,660	1,828	792
Total	25,570	10,803	34,628	27,145	16,226	11,843

UNITED KINGDOM LEAD IMPORTS (*a*)

From	1918.	1919.	1920.	1921.
Spain	49,977	39,502	58,149	66,333
U. S. A.	61,576	53,008	9,756	11,716
Mexico	.....	2,114	1,049	.....
Australia	85,280	93,276	57,987	12,534
Elsewhere	11,099	29,710	35,909	42,019
	207,932	217,610	162,850	132,602

(*a*) British Board of Trade Returns.

During the last 50 years lead mining in the United Kingdom has suffered a serious decline. This is clearly shown by the uninterrupted fall in production during that period. In 1863 the production of dressed lead ore, of about 80 per cent. lead content, amounted to 91,283 long tons. By 1913 it had fallen to 24,282 tons, and by 1918 to 14,784 tons,

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the latter figure being equivalent in terms of lead (the lead concentrate is taken to contain 74 per cent. of recoverable metal) to 0.93 per cent. of the world's production, and slightly less than 6 per cent. of the normal British consumption. At the present price of the metal lead mining should be a profitable undertaking, and some material increase in production may be looked for.[1]

India.—The report of the Burma Corporation makes anything but pleasant reading for shareholders in that concern, for not only have anticipations not been anything like fulfilled, but a serious modification or cancellation of plans of extension is envisaged. This, however, has become the common fate of programs based upon the world-wide belief that an era of peace and prosperity was at hand when the war ended. The result, so far as the Burma Corporation is concerned, is the decision:

(*a*) To close up the construction of the zinc works in India, as financial considerations prevented the Government of India contributing the anticipated loan and the Tata Iron and Steel Co. desired to limit its participation.

(*b*) To discontinue the erection of the new lead smelter, and to rely upon the extension and improvement, at a much smaller cost, of the existing smelter.

(*c*) To suspend for the time being all further expenditure on the development of the Namma coal field.

Instead, therefore, of treating over 1500 tons of ore a day, the silver-lead program now in sight provides for the annual output of 45,000 tons of refined lead, and of 4,500,000 oz. of silver from a daily treatment of 700 tons of ore. This is, nevertheless, a great advance upon present figures. The canceled program involved the construction of a smelter having an annual capacity of 60,000 tons of lead, and of 5,000,000 oz. of silver. Construction work was actually started, and £1,000,000 was raised on debentures to enable the plans formulated to be carried out.[2]

At the last annual general meeting of the Burma Corporation the Chairman referred to the appointment of E. P. Mathewson to visit the property, who has now issued his report. The conclusions arrived at are as follows:

1. That a daily average production of 700 tons of ore can be maintained when the necessary labor force is secured.

2. In order to treat this ore currently, the facilities for transportation by rail must be adjusted, and these can be provided when required.

3. To treat this tonnage of ore at a minimum cost, many improvements must be made at the smelter, most of which are in progress.

[1] *Suppl. to Comm. Rept.*, 1922.
[2] *Metal Bull.*, Nov. 17, 1921.

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The Directors wish to emphasize strongly the fact that the report deals only with the immediate policy of the Board, which aims at bringing the existing plant at the earliest date possible up to a capacity of 45,000 tons of refined lead, and 4,500,000 oz. of silver per annum, requiring a daily mine output of 700 tons of ore. The report does not take into consideration any increased production beyond these figures when labor and transport conditions permit, or the realization of the zinc contents of the ore, as soon as remunerative prices are obtainable.[1]

Rhodesia.—In these days of depression in the metal markets it is remarkable that a lead mine in the center of Africa should be making profits and paying dividends. But this is what, is spite of so many disadvantageous circumstances, the Rhodesia Broken Hill Development Co. has been able to do. During 1920 the yield of lead was 14,602 tons, obtained by smelting 42,806 tons of ore; the net profit, after allowance for depreciation, was £89,949, out of which £35,000 was paid as dividend, at the rate of 10 per cent., the remainder being kept in hand until income tax and excess-profits duty are settled. The deposit belonging to this company, situated in Northern Rhodesia, is one of the most interesting of all those controlled in London.[2]

Spain.—Lead ore is mined in 12 provinces of Spain, but the majority of the output comes from the Provinces of Jaen and Murcia, in the southern part. Jaen produced 70,220 metric tons out of the total of 136,180 tons for the country; Murcia's output was 33,625 tons. Lead production for 1919 decreased greatly as compared with 1918. Eight smelters refined 101,544 tons of lead in 1919, the largest factory, located in Cordoba, producing 45 per cent. of this amount. The refining and exportation from Huelva of 14,955 tons of lead ingots in 1920 is to be noted, as there was no export of lead in this form in 1919.

The 1919 production of silver-bearing lead was 41,875 tons—almost all from the 10 mines located in the Province of Cordoba, although a number of small mines are worked in the Province of Almeria. The year 1919 was the rejuvenation of this branch of the mining industry, which had fallen to a low figure in 1918.

There is only one silver mine in Spain, located in the Province of Guadalajara. Its 1919 output decreased greatly from 1918, but was not far below the normal for the decade, being 77 tons of ore, from which about one ton of silver was refined in the smelters of the same company. The total amount of silver refined in Spain in 1919 was 83 tons, all save one of which was produced by the process of separation from the silver-bearing lead ore, in the same refineries which smelt the

[1] *Metal. Bull.*, Mar. 24, 1922.
[2] *Mining Mag.*, Aug., 1921.

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lead itself. While the total production for 1920 is not yet known, the total export of refined lead from Spain in that year was 88,121 tons, about 40 per cent. of which went to Great Britain, and the total export of silver-bearing lead ore was 18,689 tons, 80 per cent. of which went to Great Britain.

The 12 Spanish lead refineries in operation in 1919 turned out 125,721 tons of lead, valued at 68,907,963 pesetas at the refineries. These figures include the output of the four argentiferous lead refineries at Murcia, whose production amounted to 24,177 tons. The total production in 1919 fell 43,988 tons short of the 1918 production, and represents a decrease in value of production amounting to 40,700,849 pesetas. The principal refineries are located in the Provinces of Cordoba, Murcia, and Jaen.[1]

In an article on the Spanish lead industry, published in the *Revista Minera*, strong objections are raised to the proposed new export duties, which have been fixed at 30 pesetas (gold) for lead ore, 40 pesetas for silver-lead ore, and 50 pesetas for bar lead. The writer states that lead mining, contrary to the general opinion, is to-day far from being a paying industry, and that the large majority of the Spanish mines—in fact all except three—are in such an unsatisfactory position as regards the amount of metal produced that they have continually to make adjustments in order to cover their costs. In support of this statement reference is made to official statistics, according to which the production of lead in Spain up to the year 1913 amounted to 200,000 tons per annum. Since then the returns show a steady decrease, the figures for 1920 being only 100,000 tons, while the estimate for 1921 is no higher than 60,000 tons. It is held that such a falling-off during years both of war and of peace cannot be attributed to any cause other than that the industry is no longer remunerative and offers no inducement to development. Some mines have already closed down, and others are working at a loss in hope that the present industrial depression is only transitory. Only a very small proportion of the Spanish production can be consumed in Spain, and the industry is dependent on the export trade. If the present position is to be aggravated by the imposition of crushing duties in addition to those already levied, Spain will be unable to compete with the other producing countries. Persistence with the proposed new tariff will therefore, in the opinion of the writer, lead to the shutting-down of all the mines and smelting works with the exception of the three undertakings alluded to previously, and will have disastrous effects on all the other industries dependent on them.[2]

[1] *Suppl. to Comm. Rept.*, 1922.
[2] *Min. Jour.*, Sept. 3, 1921.

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SPANISH EXPORTS[1]

Silver Lead

To	1917.	1918.	1919.
Belgium	.....	.....	300
France	464	227	3,319
Great Britain	20,239	14,937	17,678
Holland	.....	.....	.....
Other countries	715	1,198	.....
Total	21,418	16,362	21,297

Soft Lead

To	1917.	1918.	1919.
Belgium	.....	.....	14,420
France	46,649	39,858	48,381
Great Britain	44,845	34,792	16,377
Holland	926	.....	1,959
Italy	27,036	47,180	3,705
Portugal	1,253	3,166	638
Other countries	12,751	2,415	1,960
Total	133,460	127,411	87,404

[1] *Metal Bull.*

Tunis.—The majority of the lead ore of Tunis is treated in the Megrine works in Tunis itself, so that exports of ore represent much less than the production. In 1921 the exports amounted to 5997 metric tons, while the production was probably as much as 25,000 tons. Metallic lead to the amount of 8739 tons was exported to France and 6445 tons to Spain in 1921. Nearly all of the ore also was sent to France and Spain.

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Progress in the Metallurgy of Lead

By R. G. Hall

It was hardly to be expected that the year would have much to record in new development in metallurgy, and if one were looking for spectacular advances or new discoveries there would be nothing to record. But the same might be said of any period since the introduction of blast-roasting, and yet progress has been made in the art. A year such as 1921 has reacted on the industry in ways not experienced in more prosperous times. Where plants have remained in operation at all—and in few cases

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has production ceased—decreasing margin of profit and great curtailment of operations were met by increased economy, both in cost of operation and in metallurgical recovery.

Advantage was taken, in some cases, of a slack year to make extensions and reconstructions, but these have been usually the consummation of plans made in more prosperous times and in the direction of perfection of present operations or the increase of recovery from operations hitherto below a satisfactory level. A period of rapid expansion, followed as in recent times by an inflation of costs of operation and construction, is not the most desirable time to make proper provision for future economies of operation or perfection of technique.

The statistics of output elsewhere in this volume will make sufficiently clear the extent of curtailment in nearly all the active smelting fields. Colorado as usual presents the most dismal picture. From a position in the van a few years ago with upwards of forty blast-furnaces in eight smelting plants all on lead charges, there has been a decline of nearly 80 per cent. in number of furnaces operating, and the active plants have been reduced to one actually operating and one keeping alive with a single furnace. Ten years of steady and rapid growth for the State and the industry, marked, one might say, the "Golden Age" of lead metallurgy. Read the names of the "Great Ones" of the art today and yesterday, and see how many of them graduated from Colorado. There have been 20 years of gradual decline and slipping into oblivion. Perhaps the time is not yet to write the obituary, but it was a fine old industry in its day.

Statistically, at least as regards the capacity for production, the other states show but little absolute change; and returning prosperity and an increasing demand for lead are calling back the idle plants.

In the Mississippi Valley plants some reconstruction was done. No changes in metallurgy have been involved. The use of the ore-hearth has not been materially extended in this field. In fact it may be said that perfection of methods of roasting and smelting are making competition on certain ores such as those of southeast Missouri extremely interesting and extremely keen, and local conditions as to labor supply or perhaps a slight difference in grade or composition of the concentrate will decide the method best adapted to the work. Further reference will be made to this district under other headings.

The closing down of plants in the New York harbor district naturally affected the smelting plants selling them bullion, both from the western United States and from Mexico. There are no changes to be recorded from that district.

Utah, the Northwest, and the Pacific Coast, particularly the former, are the most interesting to the metallurgist at present. In Utah the

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"smoke farmer" has kept the metallurgist busy, and has really forced upon the latter the necessity of doing things which in the end have been profitable for both. The work done at Murray and Midvale in this connection will be touched on in a later paragraph.

At Trail has to be recorded about the only case of expansion of capacity which has come to notice. The work being done in this plant, both in roasting and blast-furnace work, is worthy of note, and will be referred to later.

Roasting and Sintering.—The tendency to elimination of the simple reverberatory roaster and the development of the double roast on Dwight-Lloyd machines undoubtedly continues. Even certain plants already equipped with roasters as preliminary to sintering plants are finding it profitable to discontinue the use of the roaster and employ the Dwight-Lloyd machines for double roast. This is not to say that such a course will in all cases be profitable. The reviewer would not attempt to lay down arbitrary lines for the practice. It is evident that where there is a charge of such a nature that the sulphur is too high for a good preliminary roast on the Dwight-Lloyd, the reverberatory must be employed; and where a charge is of a so-called self-roasting character down to the limits of a final sintering charge, again the reverberatory is indicated. In lead metallurgy both these cases can be covered by the statement that where pyrite forms a material part of the charge, there the sulphur generally will be high, and at the same time the thermal conditions of roasting will be such as to point to the reverberatory furnace as the apparatus for preliminary roasting. Recent work on the Dwight-Lloyd machines, perhaps somewhat of an experimental character, indicates that the field for these machines may be even further extended to include much if not all the preliminary roasting done by the lead smelter under all conditions.

Specific examples could be cited from recent practice. The work done at Port Pirie, Australia, by means of granulated slag to dilute the charge and give better conditions for a preliminary roast has been made familiar to all. There has, however, been a tendency to follow this work under other conditions not quite parallel, and to consider that the advantages gained from the use of granulated slag in the particular case cited must always follow and be profitable.

The points to be noted are:

1. The charge was too high in sulphur for good preliminary roast. It is evident that no limit of sulphur can be stated for this. A high-lead charge is more fusible and hence will not permit so much sulphur as a low lead.

2. The charge was of a dense and non-porous character. Hence

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any material which improved the penetration of the gases had to be of benefit.

3. The charge was high in zinc, hence had great exothermic value, and the internal heat developed caused fusion rather than sintering.

4. The slag used was low in zinc and hence could be used for the carrying of further amounts of zinc up to its saturation point.

5. The slag used was high in lead and hence there was some return for its use in the blast-furnace.

In the light of the above conditions it is of interest to examine three typical examples of double roasting:

A. A plant in the Middle West is treating a lead concentrate by double roasting. The charge consists of lead concentrates, first matte, and slag. The conditions prevailing are, referring to the cases above:

1. Much too high sulphur, for this character of material, to put on the machine.

2. The slag used was of some value for its lead contents.

B. A plant in the Northwest (Trail) is treating by double roast ore having rather high pyritic and zinc contents. The ore is given a preliminary sintering, and recrushed, then to the recrushed sinter is added granulated slag, about 15 per cent., before making finished sinter. The finished sinter is of superior quality and its sulphur is not over 1.5 per cent. Here at least one of the factors above laid down will apply.

1. Too high sulphur for a good-quality final sinter. It is evident that here the metallurgist has made nearly the shortest possible cut to a good final product. The original charge is of such physical condition as to permit a good-quality preliminary sinter, but not sufficiently low in sulphur. The function of the slag—in the absence of any information on its composition—must be assumed then to be purely that of a diluent to bring the sulphur to a low-enough point to make a good final sinter.

C. A plant in Asia (Burma) is treating a zinc-lead concentrate and some crude ore, with a flux of ironstone. The ore and concentrate mixture contains about 40 per cent. lead and 20 per cent. zinc, with some pyrite, and total sulphur 20 to 21 per cent. The ironstone is a limonite crushed fine, and is in sufficient amount to flux the zinc. The condition, then, of this charge is:

1. High sulphur, high lead.

2. Dense and non-porous, making great difficulty in penetration of gases.

3. High zinc.

4. No slag is available which wos not already saturated with zinc for its composition,

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5. No slag is available having recoverable lead values commensurate with its blast-furnace cost.

This problem has been met by returning recrushed finished sinter. This material has the desired qualities of porosity, dryness (to offset the very wet concentrates), and low sulphur, and enables a prime sinter to be made of 8 to 9 per cent. and a final of about 2 per cent. sulphur.

The three cases above cited may be considered typical ones for illustration. It is not the duty of the reviewer to comment on the policy of the metallurgists who have worked out the problems each to suit his own conditions. The cases will be referred to hereafter under slags.

Blast-furnaces.—With about two-thirds of all the furnaces in the Western or Rocky Mountain field out during the year, there is not much to record. Perhaps most has been done in the formation of zincy slags, and the three examples taken above in roasting will again be cited in this connection. The slags are as follows:

A. 25 per cent. SiO_2
42 per cent. FeO
8 per cent. CaO
4.5 per cent. MgO
12.5 per cent. ZnO

Here the difficulty of high zinc is complicated by the fact that high magnesia and lime already exist in the concentrate, and this is met by using considerable excess iron. This slag is clean of lead, and of course gives some, but very little, matte.

B. 18 per cent. SiO_2
40 per cent. FeO
9 per cent. CaO
23 per cent. ZnO

No difficulty has been experienced with this slag. It is clean of lead, and gives no matte.

C. 18 per cent. SiO_2
36 per cent. FeO
6 per cent. CaO
28 per cent. ZnO

This is the highest-zinc slag recorded for clean continuous running. In addition, it fits the case commercially as well as metallurgically. Where the zinc contents of the charge constituents require, this plant has run up over 30 per cent. ZnO and experienced no more difficulty. No matte is made, the charge is low in copper, and the slag contains about 2.5 per cent. lead. The trouble on the furnace and the lead in the slag vary directly with the sulphur in the charge. The whole charge is sinter where possible, except about half the lime contents.

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At Trail a change has been made from center to side feed on the blast-furnaces. This has resulted in a change in analysis of the fume recovered from zinc 20 per cent., lead 49 per cent., to zinc 35 per cent., lead 34 per cent., the tonnage remaining practically the same, indicating materially lower volatilization of lead.

Refining.—The work done in removing copper from base bullion before refining has been about the only noteworthy feature of the year. This consists in stirring into the bullion flowers of sulphur, resulting in removal of large quantities of the copper and better preparation of the bullion for the subsequent softening and desilverizing operations. At the date of writing, details of the process for purposes of publication are lacking.

At the Bunker Hill smelter at Kellogg there have been installed 100-ton desilverizing kettles instead of the 50-tons formerly in use. This increases the capacity of that refinery to 400 tons of refined lead daily, and the larger kettles have many advantages in fuel, cost, and operation over the 50-ton kettles.

At this plant also there has been developed an improvement in the condenser of the Faber-du-Faur zinc distillation furnace, patented by Mr. Archie Donaldson, of that works. It consists of a tile pipe inserted through the center of the condenser at right angles to the longitudinal axis. The condenser can as usual be either of iron or graphite. The tile pipe through the condenser gives extra area for condensing the zinc fumes, and allows the retort to be driven faster. The ends of that pipe can be plugged up or opened at will to aid in controlling the temperature of the condenser, and the rate of condensation. The attachment has materially reduced the time required to distil a charge of zinc by permitting faster condensation.

In this plant also a great advantage is obtained from the use of pulverized coal over the fuel oil formerly employed.

At this plant also the use of the Miller casting machine is said to continue successfully.

The work done with the electrolytic lead-refining process at Trail has always been of the most advanced character. Improvements there during the past year, especially in the better washing of anode slimes, and in other ways have resulted in marked economies in operation and saving in acid. The actual cost of operation by the Betts process today as worked out at Trail will compare very favorably with the cost by the Parkes process. When the very high purity of the electrolytic lead is taken into consideration it is evident that the field for this process is rapidly becoming a broader one.

Much experimental work in the past has been devoted to the

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elimination of the losses and by-products from the lead refinery. Where antimony, arsenic, and copper, as in many cases, exist in the bullion, it inevitably follows that a complex operation is necessary for recovery or elimination of the metals from the large amount of lead in the skimmings. Since the termination of the demand for this material for ammunition, antimonial lead has mostly been a slow sale, and indeed is never a desirable material in any time of normal demand. It is to be hoped that some of the experimental work now going forward will enable the smelting plants to market all their lead product as well as some of their copper, antimony, and arsenic in a more desirable form.

The manufacture of germicides and insecticides for the use of the horticulturist and the agriculturist demands an increasing supply of arsenic, most of which is being met by the copper and zinc smelters of the Rocky Mountain districts. Even the boll weevil of Texas, relentless in his invading march from the Mexican border in the direction of the Atlantic Coast, may meet by means of the arsenic of Utah and Montana a long hoped for defeat. Arsenite of calcium is said to be giving most encouraging results. Other arsenic compounds such as the sodium salt are in use for weed extermination, but it is obvious that there are narrow limitations to the use of an arsenical compound in this way.

The employment of sulphide of antimony in rubber manufacture is not of recent development by any means; but that use would absorb most if not all of the antimony now going out as antimonial lead, if and when a commercial method of separation has been perfected.

The increasing use of the high-lead alloy now marketed as Ulco or Frary metal is also limiting the use of antimonial lead which formerly formed the base of most of the low-priced babbitts on the market. Ulco metal, an alloy consisting of 97 to 98 per cent. lead, about 2 per cent. alkali-earth metals, and small quantities of other hardening constituents, is already replacing large quantities of the high-grade tin-base babbitts as well as of the lower-grade antimonial-lead-base metals. There is a decreasing need therefore for the antimonial lead of the lead refiner, and an increasing need for antimony in other forms.

General.—Fume recovery, as stated above, has been forced upon the metallurgist. In most cases he has made a virtue out of a necessity, and now finds his bag-house or Cottrell apparatus a source of profit. Probably in no one field has more useful work been done in recent years than in fume recovery and treatment. It is questionable today whether either the bag-house or the Cottrell process could be considered in the lead, and no definite answer can well be given. The tendency has been to use the Cottrell on such material as roaster gases, which are generally wet, acid, and variable in composition; and use the bags for blast-furnace and

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refinery products. These divisions are general, but there are exceptions on both sides. Probably on account of its greater simplicity of construction and operation the bag-house is more in favor among lead metallurgists where conditions at all permit of its use.

The tall stack at Midvale has already been described in the literature. It has been installed for the purpose of diffusion of the gases at a greater altitude. Mr. L. D. Anderson, Chief Engineer, has been kind enough to give further details. The connecting flues from bag-house to stack are of transite board painted with an asphaltum paint. This transite is attached inside and out to a steel framework of 4-in. I-beams. The intermediate space is filled with granulated cork for heat insulation. Two furnaces installed at the base, each equipped with two 9-in. American stokers, heat the gases and greatly aid to dissipate them after exit at the top of the stack.

This same principle of heating the gases at the foot of the stack is now in use in a number of plants, and has become established practice. Lead-smelter gases after passing through bag-houses or other fume-recovery processes are at a low temperature and most generally high relative humidity. The temperature difference is frequently insufficient to produce the requisite draft at the treatment plant, and the gases leave the stack sluggish and heavy,—the poorest possible condition to facilitate diffusion into the atmosphere. Heating of the gas has had a remarkable effect in increasing the velocity upward at the exit of the stack, and by decreasing the specific gravity has proportionally increased the rate of diffusion and the height above the top of the stack at which this takes place.

At the Midvale plant also there has been further extension of coal-dust firing for subsidiary operations, as well as for those covered by the 1920 review.

Mr. E. H. Hamilton seems to have successfully solved the application of coal-dust fuel to the lead blast-furnace. The furnace equipped ran continuously for eight months and the shut-down at the end of the period was for reasons unconnected with the coal installation. One-third of the coke was replaced by coal.

At Trail under Mr. S. G. Blaylock there has been about the only extension of plant or material improvement leading to increased output of which there is any information. Here there has been installed a thawing house of concrete construction, of a capacity of 18 railway cars daily. It is coal-fired with continuous flues running between and underneath the rails, and has been markedly successful. Three standard Dwight-Lloyd machines have also been installed. An extension of the lead refinery is now in hand, from the present capacity of 90 tons to a capacity

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of 150 tons daily. The high quality of the lead produced by this plant is already widely known.

Perhaps the most notable new developments have been in the work done by the Bureau of Mines and others in chloride volatilization of lead and other metals. No commercial installations are at present operating, but the results on a semi-commercial scale have been sufficiently encouraging to lend hope that they may in the near future lead to commercial developments.

Attention is called to the work at Good Springs, Nev., on Yellow Pine ore. Here a recovery of 70 to 80 per cent. of the lead and 90 per cent. of the silver present in the ore was obtained. Recovery of fume was by a Cottrell apparatus. The temperature of the furnace was about 1000° C. and salt was used as reagent.

At the Blaisdell mill at Pachuca a plant has been erected, but has not yet been operated. The plant is equipped with a kiln of about 8 by 125 ft. and is of capacity of 125 tons.

Undoubtedly the developments in this process will be worth watching.

Chemical methods for treatment of mixed or complex ores are exemplified by several patents issued during the year, all based on the conversion of the lead and silver to chlorides and separation from the other constituents of the ore by various means.

Elmore proposes treatment of the ore by a saturated brine (NaCl) solution, to which has been added 10 per cent. sulphuric acid. In order to obtain solution of the silver it has sometimes been necessary to subject the ore to a preliminary heating with or without the previous addition of reagents. The solution above mentioned is heated, the ore is added slowly, and heating and agitation is maintained until solution of the lead and silver is maintained. The insoluble material is decanted, the silver precipitated from the solution by means of metallic lead, lead chloride and sulphate separated by cooling, the solution brought up to strength in salt and acid and returned to the circuit.

The final products are:

(1) Ore residue containing unchanged all of the ore except the lead and silver and their combined sulphur; (2) silver slimes precipitated on lead; (3) lead sulphate containing some chloride; (4) hydrogen sulphide, proposed to be converted to sulphuric acid.

The reagent required is mostly sulphuric acid, proposed to be recovered from the hydrogen sulphide. The waste of salt is claimed to be low and probably is low. The reduction of the lead from the sulphate is claimed to be simple and inexpensive. Probably lead metallurgists who have had experience with the reduction of lead sulphate in the usual

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routine of their plants will preserve an open mind on this point. The reaction vessels are lined with rubber, and long life is claimed.

Heating of the solution is done by an ingenious method through fused silica tubes.

The process had not been put into application on a commercial scale at last accounts; but negotiations were said to be on for a plant in Burma.

Patents recently issued show that Amalgamated Zinc (De Bavay's), Ltd., have been working along the same lines as Elmore, except that they apply the hydrochloric acid direct. Nothing has been published except the patent specifications. Elmore seems to have the advantage in making the muriatic acid directly in the reaction apparatus.

Patents

Lead Alloys.—Alloys[1] composed mainly of lead, *e.g.*, an alloy formed of Pb 97.88 parts, Ba 1, Ca 0.50, and Hg 0.25 part are improved as to fluidity and tendency to dross by alloying with Al 0.02, Sn 0.25, and Zn 0.10 per cent. The alloy is suitable for the manufacture of bearings.

Alloys[2] consisting mainly of lead are hardened by the addition of about 1 to 3 per cent. of lithium. 1 per cent. gives an alloy of 17 Brinell hardness and 2 per cent. a hardness of 25. Mercury in amounts of 0.10 to 2.00 per cent. also increases the hardness.

An alloy[3] suitable for the manufacture of bearings is composed of lead with mercury 1 per cent. or less and potassium 1 per cent. or less, with or without small amounts of aluminium, tin, or zinc.

A hard alloy[4] suitable for making bearings is formed of lead with magnesium 2 per cent. or less and mercury 0.5 per cent., with or without small amounts of aluminium, tin, or zinc.

The hardness of base lead alloys[5] containing over 90 per cent. lead, *e.g.*, alloys containing lead and calcium or barium or strontium or sodium, potassium, magnesium or lithium 0.5 per cent., is regulated by the addition of a small proportion of mercury, which serves to increase the hardness of the alloys when added in an amount of 0.25 per cent. of the alloy. Very small amounts of aluminium, tin, or zinc may be added.

Hard alloys[6] adapted for use in bearings are formed of Pb 97–99.25 parts, Ba 2–0.50, and Ca 1–0.25 part.

A lead alloy suitable for bearings[7] contains about 3 per cent. of calcium and either about 1 per cent. each of strontium and barium or about 0.5 per cent. of barium. A lead alloy containing about 3 per cent. of calcium and about 0.33 per cent. of cadmium or bismuth or both is also referred to.

Antifriction Alloy.[8]—An anti-friction alloy suitable for bearings exposed to high pressures is formed of Pb 79 per cent., Sb 12, Sn 6, Cu 2.5, and P 0.5 per cent.

Alloys of Alkaline-earth Metals.[9]—A heated mixture or alloy of an alkaline metal and another metal, *e.g.*, an alloy of sodium with lead, is treated with a molten mixture

[1] E. De Campi, U. S. Pat. No. 1,360,272, Nov. 30, 1920.
[2] W. A. Cowan, U. S. Pat. No. 1,360,269, Nov. 30, 1920.
[3] G. H. Worrall, U. S. Pat. No. 1,360,346, Nov. 30, 1920.
[4] G. H. Worrall, U. S. Pat. No. 1,360,347, Nov. 30, 1920.
[5] G. H. Worrall, U. S. Pat. No. 1,360,348, Nov. 30, 1920.
[6] T. F. Wettstein, U. S. Pat. No. 1,360,339, Nov. 30, 1920.
[7] W. Mathesius, Brit. Pat. No. 156,552, Jan. 5, 1921.
[8] L. M. Parkhurst, U. S. Pat. No. 1,359,194, Nov. 16, 1920.
[9] G. J. Kroll, U. S. Pat. No. 1,359,813, Nov. 23, 1920.

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of $CaCl_2$ and CaF_2 or $BaCl_2$ and BaF_2 in order to form an alloy of lead with calcium or barium. Aluminium-magnesium alloy is formed from aluminium, sodium, cryolite, and $MgCl_2$ or MgF_2. Beryllium and copper may be similarly alloyed.

Alloy Adapted for Use in Combining with Other Metals.[1]—An alloy suitable for reduction or melting of other metals is formed of Pb 30–50 per cent., Cu 47–68, Ni 1–5, As 0.5–1.5, Mn 2.5, P 0.5, and Fe 0.5 per cent.

Alloy-coated Wire.[2]—Iron or steel wire to be alloy-coated is introduced into a molten bath formed of Pb 91 per cent., Sb 8, and Zn 1 per cent., and removed from the bath in a vertical direction so that excess coating-metal drains back into the bath and wiping of the wire is rendered unnecessary.

Alloying or Coating Aluminium with Other Metals.[3]—Aluminium plates may be coated with lead chloride and urea. When this mixture is heated on the aluminium, the lead forms a firmly adherent coating in which any aluminium which may penetrate the coating is rendered passive and not readily oxidizable. Plates of this kind may be used in making grids of storage batteries or containers for acids or other corrosive liquids which would attack aluminium. Instead of urea, it is suggested that other similar amino compounds might be used.

Furnace for Reducing Ores and Similar Purposes.[4]—The furnace is adapted for smelting copper, lead, or iron ores or other materials.

Shaft Furnace for Treating Ores.[5]

Mechanically Operated Scotch Hearth.[6]—The patent specifies a smelting furnace which has a stationary hearth, a poker, a movable support for said poker, means for moving the poker into the material on the hearth, and means for moving the support.

Smelting Furnace Operation.[7]—Charges of mixed constituents, *e.g.*, lead or silver ore, fuel and flux, are dumped at different parts of a smelting furnace so that the quantity of each constituent in the complete charge is the same in any vertical line through the complete charge. Air is forced into the sides of the charge through tuyeres near the bottom of the furnace shaft, and gases are vented above the tuyeres.

In smelting ores[8] such as lead ores a blast of air and finely divided fuel is introduced into the charge at a point within the interior wall of the furnace so as to prevent escape of the fuel up the walls of the furnace.

Treating Lead Carbonate Ores.[9]—Lead is dissolved from carbonate ores by treating the ore with a solution of NaCl and $FeCl_2$, $FeCl_3$, $FeSO_4$, or $Fe_2(SO_4)_3$.

Extraction of Lead from Sulphide Ores.[10]—Lead is extracted from its sulphide ores by grinding the ores in a neutral brine, leaching with $FeCl_3$ to dissolve the PbS and electrolyzing the solution to deposit the lead and regenerate the $FeCl_3$.

Treating Complex Ores.—Complex ores[11] or their products are roasted with an alkali chloride at about 400° or lower with access of air so as selectively to chloridize the lead and silver or at similar or higher temperatures so as to chloridize all the metals, and the product is then leached with hot alkali-chloride solution to dissolve the lead and some silver, and afterwards, if desired, with a solution of $Na_2S_2O_3$ to extract the silver. The first leaching solution is treated with metallic zinc, galvanized iron, aluminium, or the like to obtain the lead and silver, and the deposited metal may

[1] J. E. Holder, U. S. Pat. No. 1,359,064, Nov. 16, 1920.
[2] J. L. Schueler, U. S. Pat. No. 1,357,907, Nov. 2, 1920.
[3] O. F. Reinhold, U. S. Pat. No. 1,362,739, Dec. 21, 1920.
[4] R. J. Anderson, U. S. Pat. No. 1,362,212, Dec. 14, 1920.
[5] J. Labarthe, U. S. Pat. No. 1,370,215, Mar. 1, 1921.
[6] A. S. Moses, Can. Pat. No. 208,872, Feb. 22, 1921.
[7] J. Labarthe, U. S. Pat. No. 1,376,947, May 3, 1921.
[8] E. H. Hamilton, U. S. Pat. No. 1,362,570, Dec. 14, 1920.
[9] N. C. Christensen, U. S. Pat. No. 1,390,603, Sept. 13, 1921.
[10] Wm. H. Hannay, Can. Pat. No. 210,188, Apr. 5, 1921.
[11] H. J. E. Hamilton, Brit. Pat. No. 152,289, Oct. 8, 1920.

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be compressed under water to avoid oxidation, and is finally melted down. The second leaching solution is mixed with a salt solution and similarly treated to obtain a richer argentiferous lead; or the metals may be obtained from both solutions electrolytically. The residue from the leaching is treated by the "acid-oil froth process" to obtain a zinc concentrate.

Sulphide ores[1] are treated with molten $ZnCl_2$ to convert the silver and lead sulphides to chlorides, and sufficient zinc is added to the melt to reduce the silver and only part of the lead. This silver and lead are separated from the melt and the resultant mass is poured into water, from which the lead may be extracted by adding zinc.

Treating Lead and Silver Ores.[2]—In a process in which lead-zinc sulphide ores containing silver are treated with brine or the like and an acid such as HCl, H_2SO_4, or alkali bisulphate for dissolving the lead and silver and leaving the ZnS unattacked, the solubility of the silver is increased by a suitable heat-treatment of the ore or of the residual ZnS when containing silver. The heat-treatment may be a simple heating in a closed vessel or in an open vessel in contact with air, or in a neutral or reducing atmosphere such as CO_2, CO, H, and N, temperatures of 400–700° C. being mentioned, the time of heating being about 1 hr. Alternatively, the heat-treatment may be effected in the presence of a reagent which acts upon some or all of the PbS, for instance, a halogen salt such as NaCl in the presence of an oxidising gas at a temperature above 400° (and in this case the temperature may be high enough to volatilize some of the lead as chloride or oxychloride), the conditions, however, being such that the ZnS remains for the most part undecomposed; a temperature of 861° is mentioned in this connection. The solvents mentioned are NaCl, $MgCl_2$ or $CaCl_2$ containing HCl or a salt such as $CaCl_2$ or both.

Silver and Lead Chlorides.—Silver and lead are recovered as chlorides[3] from sulphide ores, concentrates, slimes, etc., particularly those containing lead, silver, and zinc, by treatment with a chloridizing gas at such a temperature that only the lead and silver are attacked. The operation is conducted in a closed furnace or retort in the absence of air, and intimate contact between the gas and the solid is ensured by rabbling, passing the gas through layers of the ore, etc., or by allowing the latter to fall through an atmosphere of the gas. The treatment is preferably carried out between 450 and 600° C. and the chloridizing gas may be generated *in situ*. In an example, a Broken Hill ore containing silver, lead, zinc, and copper, is treated with gaseous HCl at 450°. The silver and lead are leached out from the treated product either separately or together by solvents in the known manner.

In the treatment of complex sulphide ores[4] in which the ore is treated so as to chloridize the lead and silver but not the zinc, for instance by heating with $ZnCl_2$, it is leached with cold brine acidulated with HCl (and saturated with $PbCl_2$ if desired) to extract the silver, and then with hot neutral brine to extract the lead.

Sulphide ores of lead and silver[5] are treated with HCl and the mixture is dried and then heated to about 500 to 600° C. in order to effect a preferential chloridizing of the lead and silver present.

Treating Lead-zinc Ores.[6]—Argentiferous lead-zinc sulphide ores are roasted with a halogen salt such as chloride of sodium, potassium, calcium, or magnesium in an oxidizing atmosphere at a temperature above 400° C., but not high enough to volatilize $PbCl_2$, the ZnS remaining for the most part unattacked. To prevent any appre-

[1] E. Langguth, Can. Pat. No. 209,092, Mar. 1, 1921.
[2] F. E. Elmore, Brit. Pat. No. 151,698, June 23, 1919.
[3] Amalgamated Zinc (De Bavay's), Ltd., Brit. Pat. No. 159,135, Feb. 11, 1921.
[4] Amalgamated Zinc (De Bavay's), Ltd., Brit. Pat. No. 151,952, Oct. 2, 1920.
[5] H. Hey, U. S. Pat. No. 1,384,465, July 12, 1921.
[6] F. E. Elmore, Brit. Pat. No. 162,026, Dec. 18, 1919.

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ciable attack on the zinc the temperature should not exceed 500°. The air employed in the roasting is preferably moistened if dry. The product of the roasting is leached with hot brine to extract lead, some silver and any $ZnCl_2$. The lead and silver are recovered in known manner, for instance, by cooling the solution and treating the deposited chlorides to separate the silver as argentiferous $PbSO_4$, the brine being used repeatedly. The residual ore is treated with a solvent for silver such as a solution containing 35 per cent. $CaCl_2$ and 3 to 5 per cent. cupric chloride or 3 per cent. HCl, or, if there is an appreciable quantity of lead, the ore is first treated with hot brine containing HCl or H_2SO_4 to extract the lead and part of the remaining silver, and then as above described to extract the remaining silver. The used brine containing Na_2SO_4 and the lead salts obtained may be treated to de-sulphate the brine and obtain $PbSO_4$. In modification, if there is some unoxidized PbS remaining after the roasting or after the leaching with brine, the ore is leached with hot strong solution of $CaCl_2$ or $MgCl_2$ containing enough HCl to convert the PbS into chloride. This effects a good extraction of the silver and renders a subsequent extraction unnecessary. It is preferred to have a small quantity of $ZnCl_2$ present in the calcination; this may be derived from the ore if it contains some easily attackable zinc, or may be added at the beginning or towards the end of the calcination, preferably as a mixture of sodium and zinc chlorides obtained by evaporating some of the brine used for leaching.

Extracting Metals.[1]—Metal-bearing ores or materials, particularly sulphide ores, are treated to form chlorides of the metals, iron and manganese, if present, being separated as oxides, and the metals are fractionally precipitated by means of alloys of lead or zinc with magnesium, calcium, sodium, or potassium, the latter being re-formed by electrolyzing the resulting chlorides, using cathodes of the heavy metals. A suitable apparatus is specified.

Chloridizing Ores and Recovery of Their Metal Values.[2]—Ores such as lead or zinc concentrates are treated with a melt of $MgCl_2$, $CaCl_2$, KCl, or NaCl to convert metal of the ore into chloride and the metal of the latter is precipitated by the action of an alloy of heavy and light metals such as lead or zinc and magnesium which are electrolytically regenerated.

Treating Lead Bullion.—A bath of molten lead bullion[3] is agitated and at the same time treated, under non-oxidizing conditions, with a reagent such as sulphur and PbO to effect separation of impurities in the form of a dross.

Bullion containing lead and antimony, silver or bismuth[4] is treated in a comminuted state with a solution of $Pb(NO_3)_2$ until a substantial portion of the $Pb(NO_3)_2$ has been converted into basic lead nitrite, and the slimes containing antimony, silver or bismuth are separated from the lead-nitrite solution.

Bibliography

Following is a list of important recent articles on lead metallurgy, together with abstracts. The latter are taken from *Chemical Abstracts.*

Anon.—The Metallurgy of Lead. *Rass Min. Met. Chim.*, **54**, 26–9 (1921). By careful control of the furnace with regard to charging, admission of air, etc., it was possible greatly to decrease the coke required for roasting.

Anon.—Tentative Specifications for Pig Lead. *Proc. Am. Soc. Testing Materials,*

[1] E. A. Ashcroft, Brit. Pat. No. 156,866, Sept. 30, 1919.
[2] E. A. Ashcroft, U. S. Pat. No. 1,388,086, Aug. 16, 1921.
[3] G. P. Hulst and M. W. Krejci, U. S. Pat. No. 1,386,503, Aug. 2, 1921.
[4] J. O. Johnstone, U. S. Pat. No. 1,389,511, Aug. 30, 1921.

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20, Part 1, 554–60 (1920). The specifications cover manufacture, chemical properties and tests, marking, and claims.

ANON.—Swain's Report on Smoke in Salt Lake Valley. *Chem. Met. Eng.*, **24**, 463–5 (1921). Following a judicial decision adverse to the smelter, the Court appointed R. E. Swain a Commissioner to decide on the conditions of operation which would permit the operation of the smelters without injury to their surroundings. This article is an abstract of the report of Swain and his staff. They recommend: careful bag-filtration of blast-furnace gases; Cottrell precipitation of roaster dusts, etc.; increased temperature of roaster gases which on discharge carry SO_3, heating them by coal furnaces near the base of the stack during the growing season; stack approximately 455 ft. high; maximum daily limit of SO_2 discharge of about 100 tons.

CROPPER, PERCY M.—Recent Developments at the Yellow Pine Property. *Salt Lake Min. Rev.*, **22**, 23–5 (1920). This mine, located at Goodsprings, Nev., the heaviest shipper of zinc carbonate in the United States, has recently been carrying on some interesting experiments, in coöperation with the United States Bureau of Mines, on the volatilization of its ores by the chloridising process. At present the grade of the zinc carbonate is simply raised by calcination. With the chloridising process it will be possible to recover 96 per cent. of the silver and 92 per cent. of the lead in the form of a concentrated fume, leaving the zinc as a concentrated residue. A Cottrell precipitator is being built for larger tests. Salt is used as a chloridising agent. The present milling operations of jigging and tabling are described, together with a general history of the property and its economic problems.

CZOCHRALSKI, J.—Bearing Metals and Their Industrial Application. *Z. Metallkunde*, **12**, 371–403 (1920). Early in the war (1915) the available tin in Germany was about 4500 tons, with a normal demand for bearing metals alone of 10,000 tons. Extended investigations of bearing-metal materials were, therefore, undertaken and are here reported in condensed form. The effects of pouring-temperatures on the common bearing alloys are illustrated by photomicrographs with special reference to the new lead-barium and lead-calcium alloys. Tables and curves show the physical properties of the alloys studied and indicate the decided advantages of the Pb-Ba bearing metals for many uses. Czochralski describes in detail, with drawings, the methods of making and melting bearing metals and the methods of attaching the bearing layer to bushings, especially with the new alloys. Correct and incorrect methods for the seating of the shaft in the bearing in connection with lubrication are illustrated. An instrument for measuring the bearing efficiency of different metals is described. The paper is followed by an extended discussion and has many photomicrographs, charts, line drawings of furnaces, and photographs of machines.

CZOCHRALSKI, J. and RASSOW, E.—The Constitution Diagram of the Alloys of Lead and Barium. *Z. Metallkunde*, **12**, 337-40 (1920). Lead-barium alloys were studied up to 8 per cent. barium and the equilibrium diagram was found to be of the eutectic type in the limited range investigated. The components of the eutectic are pure lead and a compound which is probably Pb_3Ba. The eutectic contains about 4.5 per cent. Ba and melts at 282° C. Microscopic examination confirms the results of thermic study.

GREENAWALT, WILLIAM E.—The Greenawalt Sintering Process. *Min. Sci. Press*, **122**, 81–5 (1921). The Greenawalt process is intermittent in operation, a charge being subjected to a down-draft blast of air, and after ignition the sintering action proceeds from the top downward. It is simple and present plants range from 20 to 1000 tons per day capacity. The charge to be sintered should have about 10 per cent. moisture and should be properly mixed. The sulphur content of copper and lead ores may vary from 5 to 15 per cent., and the coke content of iron ores should

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be between 3 and 10 per cent. A 10 by 24-ft. pan, the largest unit, has a capacity of 150 to 250 tons daily. The charge-car spreads a layer of non-sinterable material over the grates to a depth of ¼ to ¾ in. before dumping the charge, all of which is done in a few seconds. The ignition requires about a minute and either gas or oil may be used; with the latter about 1 gal. is used per ton of sinter. The time of sintering varies from 15 to 60 min., and the suction used from 10 to 35 in. of water. About 5 to 6.5 kw. hr. is used per ton of sinter. Sintering may replace drying of flotation concentrates, first, because the moisture contained is necessary for sintering; second, the concentrates furnish their own fuel for sintering, as against purchased fuel required for drying; third, reduction in weight for shipping and smelting, of from 15 to 20 per cent.; fourth, the saving in sacking where the fine concentrates are sacked to prevent loss. The combination of sintering and blast-furnace smelting bids fair to compete with roasting and reverberatory smelting.

GUREVICH, LOUIS J. and HROMATKO, JANE S.—Properties of Antimonial Lead. *Chem. Met. Eng.*, **25**, 62–3 (1921). Melting-point determinations are too indefinite to be used as a basis for calculating the composition of lead-antimony alloys. The addition of antimony increases the hardness of the alloy. The maximum tensile strength of the lead-antimony alloys is reached with an alloy containing 10 per cent. antimony. The alloy containing 4.5 per cent. antimony gives the greatest reduction of area and is the most ductile.

HESSON, R. B., LANDOLT, P. E., and HEIMROD, A. A.—Recent Applications of the Cottrell Process. *Eng. Min. Jour.*, **112**, 446–9 (1921). Installations of this process for the recovery of valuable metallic particles have recently been made at the plants of the National Lead Co. and the Williams-Harvey Corporation. Metallic losses of zinc, tin, and lead are prevented. A description of the mechanical and electrical features is given. Performance tests on the National Lead installation showed a recovery of 97 per cent. of the suspended matter, which consisted of 40 to 50 per cent. zinc, 15 to 20 per cent. lead and 15 to 20 per cent. tin, all as oxides. The gases are at 345° C. and 12,000 cu. ft. per min. are treated. Total cost of installation was $30,000 and annual operating charges are about $10,500. Expected recoveries will be 450,000 lb. of dust at a value of about $18,000, netting 20 to 30 per cent. on the investment. The other plant cost $125,000 complete, and returns from dust are at the rate of$100,000 per year or $70,000 above all expenses. A bibliography is attached.

LAYNG, HARAI R.—The Chloride Volatilising Process. *Eng. Min. Jour.*, **111**, 1056–7 (1921). Layng considers calcium and magnesium chlorides superior to sodium chloride as chloridizing and volatilising agents. Special treatment as regards grinding, presence of water vapor, rate of heating, oxidizing conditions, rabbling, or method of adding the chloridizer are required for some ores. High extraction by the volatilizing process has been obtained on tailings from cyanidation of Tonopah ores. Layng does not use the Cottrell system for recovery, but generally prefers an absorption system, and would use a bag-house when that method would not be suitable. The Cottrell method loses most of the chlorine. Time required and fuel consumption in the volatilization process are much lower than has been stated.

RICKARD, T. A.—The Bunker Hill Smelter. *Min. Sci. Press*, **122**, 43-60 (1921). The plant consists of crushing and sampling mill, Dwight-Lloyd sintering machines, Traylor blast-furnaces, lead and silver refineries. The sintering plant uses pulverized coal as fuel. The fume and gases from the sintering plant pass to Cottrell precipitators. The roast, flux, ore and coke are all drawn from separate bins and weighed before being charged to the blast-furnaces, of which there are four, having a combined capacity of 1200 tons per day. The charge contains 32 per cent. lead and less than 4 per cent. zinc. The slag and matte are drawn off intermittently into pots, while the

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lead is run off continuously. Fume from the blast-furnaces passes through settling chambers to a bag-house. The product from the bag-house contains 72 per cent. lead and 8 per cent. sulphur. The temperature of drossing is about 360°C. and in softening where the antimony is removed a temperature of 920° is maintained for 20 hr. Zinc for desilverizing, and the resulting precious-metal alloy skimmings are run through a Howard press for removal of lead. The refined lead is cast into pigs by a Miller casting machine. The pressed alloy is retorted for removal of the zinc and the final retort metal is sent to the silver refinery, where through the use of a Rhodes cupelling furnace any remaining lead is driven off. The silver ingots are parted in iron kettles with 66° H_2SO_4 and the silver in the resulting sulphate is deposited upon copper. The final $CuSO_4$ is evaporated to crystals. The lead refinery is equipped with a reverberatory furnace for the treatment of various drosses. A description is given of the coal-pulverizing plant, which uses the Bonnot system.

RIDGE, H. M.—Roasting Furnaces for Sulphide Ores. *Chem. Age* (London), **3**, 586–7 (1920). An historical review of the subject of roasting of pyritic ores.

RIGG, GILBERT.—Roasting and Lead-Smelting Practice at the Port Pirie Plant of the Broken Hill Associated Smelters Proprietary, Ltd. *Bull. Inst. Min. Met.*, 1920, No. 191, 1–3. It is brought out in the discussion that slags produced by smelting zinciferous lead ores from Rhodesia Broken Hill mines often contain more than 20 per cent. ZnO. They also contain 40 per cent. or more iron oxide, of which 6 per cent. or less is in ferric state. These slags may contain 18 per cent. SiO_2, 5 to 6 Al_2O_3, and 2.5 to 3.5 per cent. P_2O_5. The Fe_2O_3 is thought to be in the form of magnetite or franklinite and the zinc as Zn_2SiO_4, the latter corresponding to willemite. It is suggested that the phosphate content may have a marked effect in retaining lead in the slag.

SHEPARD, E. R.—Electrolytic Corrosion of Lead by Continuous and Periodic Currents. *Trans. Am. Electrochem. Soc.*, **39**, preprint, 23-26 (1921). Shepard conducted further study and experimental work based on the conclusions of McCollum and Ahlborn on frequencies in electrolytic corrosion. Their results agreed generally. Shepard found that with continuous currents the coefficient of corrosion of lead (1) decreases with increased current density in both tap-water and earth; (2) decreases rapidly with the water content of the earth; (3) decreases with time in tap-water, but not in saturated earth. With periodically reversed current, the coefficient of corrosion (4) decreases rapidly with time to about 14 per cent. in saturated earth, and 50 per cent. in tap-water, if the algebraic sum of currents equals zero; but otherwise (5) increases with the per cent. of total time (*i.e.*, amp. hr.) during which the anodic condition prevails. There are indications of re-deposition of lead from soil under alternating-current electrolysis.

TAFEL, VICTOR.—Losses in the Smelting Industry. *Metall u. Erz.*, **18**, 377 (1921). Losses in smelters can be divided into the following groups: (1) Losses in waste material; this includes slag losses, losses due to absorption by muffles and crucibles, and metal contents in residues and waste liquors. (2) Vaporization and dust losses. (3) Loss in market products, as for example the noble-metal content of hard and soft lead. The losses falling under (1) and (3) cannot be appreciably lessened. Those under (2) can be practically eliminated by the installation of suitable condensation apparatus. Losses in slags and waste materials can be easily calculated from the weight of the material and the analysis, as is also true of losses in market products. It is practically impossible to evaluate accurately the vapor and dust losses.

VARLEY, THOMAS and STEVENSON, C. C.—Chloride Volatilization Process. Bureau of Mines, Repts. of Investigations, No. 2247, May, 1921, 9 pp.; *Min. Sci. Press*, **123**, 159–62 (1921). Volatilization of metals as chlorides in metallurgical

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processes is still in the experimental stage, although studied for 20 years. A short history of development is given. It is especially suitable for oxidized ores of copper, lead, silver, and gold for which gravity concentration and flotation are unsatisfactory, and affords excellent means for separating lead from zinc. The latter does not volatilize under oxidizing conditions. Experiments on sulphide ores are encouraging, but these ores require preliminary roasting when more than 5 per cent. sulphur is present. Chemical and microscopical data are necessary, the former providing for calculation of chloride requirement, and the latter indicating required fineness of crushing. The reactions are probably reversible; chloride is formed at low temperature, but not volatilized immediately. High temperature probably decomposes part of the chloride without volatilization. Chloridizing reagents may be volatilized without reacting with the ore, so that the most effective method is to add the reagents to the hot ore. Addition of 4 per cent. of $CaCl_2.2H_2O$ increased volatilization of silver from 74.3 to 90.3 per cent. Baking and sintering may occur, the latter preventing chloridizing action. Ore flow, gas velocity, temperature and time are discussed briefly.

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MAGNESITE

By Samuel H. Dolbear

The depression in the metal industries during 1921 was reflected in the consumption of magnesite in the United States. The apparent consumption was 113,479 short tons of crude, of which 58 per cent. was imported.[1] Imports came chiefly from Italy, from which country over 36,000 short tons was brought in, as against about 9500 tons from Austria. Austria-Hungary formerly produced a large part of the world's supply. The change is due in part to the changes in area controlled by those countries and in part to the development of new deposits in Italy. Furthermore, some shipments of Austrian magnesite pass through Trieste, which is now under Italian control.

Normal consumption of magnesite in the United States, in terms of crude, amounts to about 300,000 tons, of which a large part is dead-burned and consumed by the steel and other metal industries. The year 1921, therefore, resulted in an apparent consumption of but little more than a third of this amount.

The entire domestic production of 47,904 tons came from California. That State produces but little dead-burned material, most of the ore being sold as caustic magnesite for other than metallurgical work.

The estimated value of domestic crude ore was $10.65 a ton, as against $10.01 for the imported material.

The value of imports was $525,452 and that of domestic production $510,177.

Of total imports but 6788 tons was calcined, the remainder, 51,993 tons, having been brought in as crude. This was probably due to fuel and labor conditions at the points of shipment.

The demand for caustic or light-burned magnesite for plastic purposes, particularly in building operations, continues to increase, and it is believed that the amount consumed for that purpose during 1921 was greater than normal. That consumed in combination with asbestos and other substances for insulating purposes was less than in previous years. Purchasing for future delivery is rare, as buyers have been awaiting the outcome of the tariff legislation.

[1] Press notice, U. S. Geol. Surv.

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MAGNESITE IMPORTED INTO UNITED STATES (a)
(Tons of 2000 lb.)

Year.	Crude, Tons.	Value per Ton.	Total Value of Crude.	Calcined, Tons.	Value per Ton.	Total Value of Calcined.
1914	13,354	$4.09	$54,677	121,816	$10.86	$1,323,194
1915	49,763	5.12	255,140	26,574	8.73	232,071
1916	75,344	8.42	634,447	9,269	22.02	204,183
1917	30,272	7.66	232,105	3,965	58.66	232,608
1918	5,432	19.00	103,233	19,049	43.25	824,022
1919	6,380	16.18	103,311	9,470	28.58	270,721
1920	33,549	12.17	406,204	14,799	25.21	373,165
1921	51,993	10.01	525,452	6,788	36.96	250,932

(a) Compiled from figures of the Dept. of Commerce.

IMPORTS OF MAGNESITE, NOT PURIFIED
(Fiscal years ending June 30, in long tons)

Country.	1917.	1918. (a)	1919. (a)	1920. (a)	1921. (a)
Europe:					
Austria-Hungary	.....	.....	2,366	.....	8,478
Czecho-Slovakia	.....	.....	.....	3,829	190
Germany	.....	.....	30	713	3,468
Greece	1,792	.....	.....	4,437	4,000
Italy	.....	.....	2,157	21,185	32,251
Netherlands	.....	.....	.....	819	2,602
United Kingdom—					
England	27	2	26	28	.....
Scotland	757	774	84	190	98
North America:					
Canada	2,148	17,860	7,202	6,028	381
Mexico	.....	.....	2,288	500	.....
Venezuela	.....	.....	.....	2,300	8
Other countries	.....	.....	.....	3,125	1,000
Total	4,724	18,636	14,153	43,154	52,476

(a) Calendar years.

IMPORTS OF MAGNESIUM CHEMICALS INTO THE UNITED STATES

	1919.		1920.		1921.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Magnesia:						
Calcined (Medicinal)	22,637	$11,358	26,859	$9,903	35,182	$7,593
Carbonate (Medicinal)	5,094	1,101	14,930	1,512	18,514	2,061
Sulphate	17,647	1,473	1,803,769	66,944	12,519,778	88,153
Chloride	11,200	537	454,334	7,098	7,365,812	85,127

UNITED STATES

The Washington mines, which produced 220,000 tons in 1920, were idle in 1921. The depression in the metal industry, competition from foreign sources, and the use of dead-burned dolomite were contributing factors in the shut-down. Washington operators continued their efforts to get a protective tariff.

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STATISTICS OF CRUDE MAGNESITE IN THE UNITED STATES
(Tons of 2000 lb.)

Year.	Production. (a)		
	Tons.	Total Value.	Value Per Ton.
1908	6,587	$19,761	$3.00
1909	9,465	37,860	4.00
1910	12,443	74,658	6.00
1911	9,375	75,000	8.00
1912	10,512	84,096	8.00
1913	9,632	77,056	8.00
1914	11,293	124,223	11.00
1915	30,499	274,491	9.00
1916	154,974	1,393,693	9.00
1917	316,838	2,899,818	9.15
1918	231,605	1,812,601	7.83
1919	156,226	1,248,415	7.99
1920	303,767	2,748,150	9.04
1921	47,904	510,177	10.65

(a) U. S. Geol. Surv.

The California output, amounting to 47,904 short tons of crude, came largely from two mines, and was used chiefly for plastic purposes. A gradual decrease in demand resulted in the closing-down of all California mines by December.

The demand for caustic magnesite for ship work held until the latter part of the year.

The U. S. Geological Survey issued the following report[1] of a large magnesite deposit recently disclosed in southern Nevada:

A massive deposit of magnesite of unusual character that has recently been brought to the attention of the Geological Survey promises to yield a large and readily available supply of this material. The deposit lies in Clark County, Nevada, in the valley of Muddy River, one of the tributaries of Virgin River, a few miles above the town of St. Thomas. The material has been known for some time as kaolin, and successful experiments for utilizing it as a porcelain clay are reported to have been made, though they have not yet resulted in the exploitation of the deposit. The recognized outcrops have been located as mining claims, and some preliminary exploration and development work has been done. A side track on the St. Thomas branch of the Los Angeles & Salt Lake Railroad, about 3 miles northeast of the northernmost group of claims, offers a readily available railroad connection, and the station has been named Kaolin from this deposit.

The so-called kaolin is stated by the Geological Survey to be in fact a magnesite and was deposited in a highly magnesian sedimentary bed, a part of a regularly stratified series of sedimentary beds exposed by stream channels that cut across a low ridge of the upper edge of Muddy Valley. The deposit forms a chalky-looking bluff, dazzlingly white in the bright sunlight. The material is porcelain-white, fine grained, and massive, is remarkably free from foreign material, and has the structureless appearance and conchoidal fracture that are generally characteristic of magnesite. It is not so hard as the more typical magnesite, and it crumbles more rapidly on exposure to the weather.

[1] Press notice, U. S. Geol. Surv., July 18, 1922.

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The deposit is included between tilted beds of conglomerate and sandstone below and shale above. The lower contact is sharply defined, but the magnesite grades up into the overlying beds. The purer part of the deposit consists of beds aggregating at least 200 ft. in thickness. Within the section of purer material there are a few bands of sandy matter, but these are minor in amount and apparently almost negligible, as they could undoubtedly be avoided in mining. The whole section lies in the form of a "hogback"—that is, the softer beds lap up against a uniform slope of the sandstone and conglomerate that has a northeasterly dip of 30 to 50°.

The region in which the deposit lies is in large part covered with alluvial wash, which conceals most of the bedrock formations, so that the section including the magnesite is exposed at only a few places where streams have cut down through the overlying deposits. The regularity of the exposed section and the continuity of the harder beds, which project through the surface wash, justify the assumption that the magnesite is practically continuous between exposures and for considerable distances beyond. Its length at the surface seems to be a mile at least.

Unlike most other deposits of magnesite in California and elsewhere in this country, this is not a vein deposit, such as occurs with serpentine, but resembles closely the deposits discovered in 1911 at Bissell siding, near Mohave, Calif., both being interbedded with sandstone and shale and of a sedimentary origin. The deposit at Bissell, however, does not appear to be so large or regular as the deposit on Muddy River. The similarity in the composition of the magnesite from the two places is shown by the analyses given below:

	Muddy River, Nev.		Bissell, Calif.
	1	2	
SiO_2	11.12	11.82	9.64
$Al_2O_3 + Fe_2O_3$	0.98	0.94	2.46
CaO	5.36	5.90	4.25
MgO	36.72	36.40	37.19
CO_2	(a)44.15	(a)43.45	40.70
	98.33	98.51	94.24

(a) Determined by loss on ignition and therefore includes moisture.

Samples of this material were noticed in a mineral cabinet at Las Vegas, Nev., August, 1915, by a geologist of the Survey, who then recognized the material as probably magnesite, though he was informed that it was kaolin. Later he visited the deposit in company with one of the claimants and was then informed that analyses made in Salt Lake City showed that it was magnesite. So far as known, however, no special importance had been attached to this fact, as the material was then being exploited at the Panama-Pacific Exposition in San Francisco under the name of kaolin. The new deposits are so large and so readily accessible that they may form a valuable source of magnesite.

The series of beds that contains the magnesite is the "Horse Spring Formation" of Tertiary age. It contains the colemanite deposits of the Callville district.

Foreign Countries

Canada.—The mines in this country are located chiefly in Argenteuil County, Quebec. Shipments of less than 1000 tons of crude were, however, made from the Lake Atlin region in British Columbia. Total

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shipments in 1921 were about 3700 tons, a heavy decrease as compared with 1920. Exports of crude ore were negligible. Magnesite exported as calcined or crude was valued at $16,453, of which 427 tons valued at $15,195 was shipped to the United States.

The North American Magnesite Producers, Ltd., operated its clinkering plant only a few months and calcined magnesite only during the last quarter. The Scottish Canadian Magnesite Co. at Grenville also operated only a part of the year.

The plant of the International Magnesite Co. calcined ore a few weeks during the latter part of the year.

It is reported that a consolidation of interests has been effected between the North American Magnesite Producers, Ltd., and the Scottish Canadian Magnesite Co., the two being operated under joint management.

Austria.—Before the war, the United States was the chief purchaser of Austrian ore. During 1920 and 1921 a large part of the production went to Germany. Shipments are largely of crude, doubtless due to local fuel and labor conditions.

Figures of imports in the United States give Austria credit for but 9500 tons during 1921. However, a part of the Austrian production passes through Italy and is accredited to that country, and Germany and Netherlands appear to have shipped 6800 tons, all of which was ore transshipped from those countries. Much of this ore probably originated at Austrian shipping points.

The Veitch Magnesite Works have acquired a Tyrol deposit and the magnesite works of Kraubarth have gone over to the Alpine Montan concern. French capital, notably the French firm of Schneider Creuzot, is reported to have become heavily interested in Austrian magnesite.

An agreement has been made between a German group and the Styrian Magnesite Co. of Austria, whereby the Germans secure the company's output of caustic magnesite for a long time ahead. This company of late has supplied Scandinavia and America.

Italy.—This country is reported to have shipped 36,000 tons to the United States during 1921. So far as is known there are no calcining plants in Italy and its shipments are all of crude ore. Deposits developed in Italy since the war are regarded as large potential producers. In 1920 the output of crude magnesite in Italy was 33,850 metric tons, but this fell to 9400 tons in 1921.

Manchuria.—A deposit of magnesite 15 miles in length, 1.4 miles wide, with a height of 500 ft. above the level of the ground, is reported to exist in South Manchuria. The deposit, which in places is but one-half mile from rail, is controlled by Japanese and Chinese. A plant was built for treatment of the ore, but is understood to have been unsuccessful.

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MAGNESIUM[1]

Only one company, the American Magnesium Corporation, of Niagara Falls, N. Y., reported a production of metallic magnesium in 1921. The quantity produced (10,044 lb.) was far less than in previous years and was, as in 1920, obtained incidentally in experimental operation of furnaces. This magnesium was made from California magnesite. The quantity of stick or ingot and powder sold or used (manufactured largely from stocks on hand) was more than four times as great as the quantity of new magnesium produced. A few thousand pounds of magnesium alloys (containing more than 90 per cent. magnesium) and much smaller quantities of castings and ribbon were also sold or used. Stocks on hand at the end of the year also exceeded the quantity of new metal produced. One other company may also have worked up stock held over from 1920, but has failed to report on its activities.

The average price for high-grade domestic magnesium sold as sticks in 1921 was about $1.60 a lb., the same as in 1920; but one lot of impure metal was sold at a specially low rate, reducing the general average price to $1.30. The average price of the powder was about $2.25 a lb.

In contrast to domestic production, imports continued to increase, amounting to 39,913 lb. in 1921, compared with 29,275 lb. in 1920 and 13,239 lb. in 1919. Imports were heavy in the later part of the year, and the low prices quoted, particularly from Germany, would have precluded competition by domestic producers even if general industrial conditions had been better. It is stated that the manufacturers of magnesium in England and France have been similarly affected, as Germany controls within its borders the necessary raw materials and with its depreciated currency can undersell in any market, in spite of its export duty and the import duties into other countries.

The tariff bill reported by the Senate Finance Committee in April, 1922, calls for a duty of 50 cts. a lb. on metallic magnesium and 50 cts. a lb. and 20 per cent. *ad valorem* on magnesium alloys.

Notwithstanding the present discouraging conditions, real progress was made during the year, particularly in improving the purity of the metal. The American Magnesium Corporation claims ability to produce commercial magnesium 99.98 per cent. pure. Magnesium is said to resemble zinc in that for structural purposes or machine parts it must be practically free from even minute quantities of certain impurities, particularly alkalies and chlorine, which cause local granular corrosion and have given magnesium the reputation of being unstable. A reported criticism of imported magnesium is that it is impure.

[1] G. F. Loughlin, *Min. Res. of the U. S.*, 1921, U. S. Geol. Surv.

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METALLIC MAGNESIUM PRODUCED IN THE UNITED STATES

Year.	Number of Producers.	Quantity, Pounds.	Value.	Average Price per Pound.
1915	3	87,500	$440,000	$5.00
1916	4	75,400	311,462	4.13
1917	5	115,813	233,626	2.02
1918	4	284,188	615,217	(a) 2.16
1919	3	127,465	247,302	1.94
1920	2	(b)	(b)	(c) 2.75
1921	1	10,044	.....	(c) 2.25

(a) As 1918 was the first year in which powdered magnesium was reported to the Geological Survey, the average price of $2.16 a pound for all magnesium sold in 1918, which includes a large quantity of powdered magnesium, is not comparable with the average price for 1917, which is based on magnesium in sticks only. The average price for stick magnesium in 1918 was about $1.81 a pound, or 21 cents less than in 1919. (b) Permission for publication not given. (c) Powder.

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MANGANESE

By Marshall Haney

Principal Features of the Year 1921.—The United States production of high-grade manganese ore shipped from mines in 1921 amounted to 13,531 long tons, of which 11,129 tons came from the State of Montana. The production of ore containing from 10 to 35 per cent. manganese was 8439 tons, most of which came from Georgia. The shipments of low-grade manganiferous ore amounted to 62,670 tons.[1]

The net imports for the year amounted to 392,606 long tons of high-grade ore and oxide, valued at $2,864,099. Brazil furnished 262,468 tons valued at $7.44 per ton and India 113,730 tons valued at $6.46 per ton.

The general business depression of 1921 is responsible for the small domestic production.

UNITED STATES PRODUCTION AND IMPORTS

(Long tons)

Year.	Ore.			Ferromanganese.			Spiegeleisen.	
	Imports. (b)	Production. (b)	Production. (c)	Imports.	Av. Value per Ton. (a)	Production.	Imports.	Production.
1912...	300,661	1,664	868,501	99,137	$39.41	125,378	1,015	96,346
1913...	345,090	4,048	672,146	128,070	44.37	119,496	77	110,338
1914...	283,294	2,635	445,827	82,997	41.33	106,083	2,870	79,935
1915...	313,985	9,709	801,290	55,263	60.31	146,542	200	93,282
1916...	576,321	26,966	548,803	90,928	101.62	221,532	*Nil.*	194,002
1917...	629,972	114,216	1,103,503	45,381	134.58	257,842	3,968	188,852
1918...	491,303	305,869	1,145,531	27,168	156.75	345,306	1,969	249,002
1919...	333,344	55,322	433,733	33,022	129.72	179,079	27	65,391
1920...	606,937	94,420	636,966	59,254	131.22	282,681	5,234	103,448
1921...	392,606	13,531	71,109	9,077	98.09	98,439	307	56,139

(a) At foreign port, no freight or duty. (b) High-grade manganese ore. (c) Ma nganiferous ore, not including manganiferous sino ore.

[1] Statistics of U. S. Geol. Surv., reported by H. A. C. Jenison.

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MANGANESE ORE AND OXIDE IMPORTED INTO THE UNITED STATES (a)
(In long tons)

Country from Which Imported.	1919.		1920.		1921.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Africa	1,388	$19,157	31,927	$123,415	8,453	$27,198
Argentina	2,305	86,547	5,500	275,000	.....	.....
Australia	548	26,365	.....	.....	.....	8
Brazil	246,592	7,177,071	421,523	8,833,493	262,468	1,952,848
British India	9,200	254,971	71,238	551,660	113,730	734,516
Canada	582	16,926	828	28,509	.....	.....
Chile	411	13,950	12,563	312,794	.....	.....
China	1	30	3,383	126,648	.....	.....
Colombia	10	969	.....	.....	.....	.....
Costa Rica	9,988	351,237	2,413	60,325	588	17,658
Cuba	35,320	1,433,202	8,247	266,744	34	679
Czecho-Slovakia	.....	.....	1,874	58,602	.....	.....
Ecuador	20	641	.....	.....	.....	.....
England	9,470	1,066,741	7,049	243,564	.....	.....
France	.....	.....	188	48,076	.....	.....
French Oceania	.....	.....	7,510	75,316	.....	.....
Germany	.....	.....	11	3,209	.....	.....
Hongkong	1,265	27,940	9,520	207,441	7,319	131,052
Japan	651	39,039	474	36,672	.....	.....
Mexico	6,295	266,307	2,925	55,449	(b)14	140
Panama	2	76	.....	.....	.....	.....
Portugal	400	31,100	.....	.....	.....	.....
Russia	6,916	296,915	18,762	858,804	.....	.....
Turkey in Europe	2,000	120,000	1,000	65,000	.....	.....
Venesuela	.....	.....	2	111	.....	.....
	333,344	$11,229,184	606,937	$12,230,922	392,606	$2,864,099

(a) Compiled from figures furnished by the Bureau of Foreign and Domestic Commerce.
(b) Honduras.

Tariff.—The manganese ore reserves in the United States should be divided into three classes:

(1) High-grade chemical ore; (2) high-grade ore and ore capable of beneficiation; (3) low-grade manganiferous and ferruginous ore.

The ore of the first class is of such character and grade and is produced at such moderate cost that it may be sold in competition with foreign ores, and these facts make its future fairly bright. Most of the ore of the second class, however, cannot be mined at a profit under normal conditions.

To meet foreign competition a tariff of 1 ct. per pound of metallic manganese in excess of 30 per cent. of metallic manganese content of ores and concentrates imported was reported favorably by the House in the Fordney tariff bill, and this was later adopted in the Senate. This tariff would impose an import duty of about $4 per ton on Russian, Indian and Chilean ores, and $3 to $4 on Brazilian ore. The Senate, however, reduced the House rates on ferromanganese, fixing them at $2.50 per ton when containing more than 1 per cent. carbon and 30 per cent. or more manganese, with a duty of 20 per cent. *ad valorem* when containing not more than 1 per cent. carbon. Spiegeleisen, containing less than 30

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per cent. manganese according to the tariff classification, was made dutiable at $1.25 per ton when containing more than 1 per cent. carbon, and at 20 per cent. *ad valorem* when containing not more than 1 per cent. carbon. It is a question of course whether these rates will stand in the bill as finally passed.

The following table shows the receipts of manganese ore from the principal sources of supply for the past 15 years, in long tons:

	Cuba.	Brasil.	Russia.	India.
1907	.....	52,922	1,000	95,300
1908	.....	17,150	250	143,813
1909	.....	35,600	14,486	145,140
1910	.....	53,750	33,120	140,965
1911	.....	41,600	19,103	106,580
1912	.....	81,580	83,334	128,645
1913	.....	70,200	124,337	147,587
1914	.....	113,924	52,681	103,583
1915	5,141	268,786	.....	36,450
1916	30,563	471,837	.....	51,960
1917	44,511	512,517	.....	48,975
1918	82,974	345,877	.....	29,275
1919	35,320	246,592	6,916	9,200
1920	8,247	421,523	18,762	71,238
1921	34	262,468	.....	113,730

Ferromanganese Supplies.—The decline in the pig-iron output of the country has been paralleled by that of ferromanganese and spiegeleisen. According to the blast-furnace returns of *The Iron Age* the production of ferromanganese in 1921 was the lowest in 10 years, while the decline in output of spiegeleisen was even more pronounced. From an average in the first quarter of the year of 19,178 tons per month, the ferromanganese production declined to an average of only 3758 tons in the fourth quarter. The total for the year was 98,439 long tons. The production of spiegeleisen ceased entirely in July, a decline from an average output of 11,667 tons per month in the first quarter. The output for the year was 56,139 tons.

FERROMANGANESE AND SPIEGELEISEN OUTPUT IN THE UNITED STATES—GROSS TONS (*a*)

	Ferro-manganese.	Spiegel-eisen.	Total.	Average per Month.
1913	119,495	126,081	245,576	20,464
1914	106,083	100,365	206,448	17,204
1915	146,542	93,282	239,824	19,985
1916	208,389	197,518	405,907	33,817
1917	287,834	188,852	446,686	37,222
1918	345,306	249,002	594,308	49,525
1919	179,079	65,391	244,470	20,372
1920	282,681	103,448	386,129	32,346
1921	98,439	56,139	154,578	12,881

(*a*) *Iron Age.*

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Monthly quotations on ferromanganese are given in the following table:

	1915.	1916.	1917.	1918.	1919.	1920.	1921.
January	$ 68.00	$110.00	$175.00	Government	$190.00	$147.00	$112.50
February	100.00	140.00	210.00	Control	160.00	160.00	100.00
March	100.00	175.00	270.00	Price,	140.00	172.50	96.00
April	100.00	175.00	325.00	$250.00	120.00	191.50	90.00
May	100.00	175.00	400.00		110.00	200.00	85.00
June	105.00	175.00	400.00		110.00	200.00	80.00
July	103.00	175.00	400.00		110.00	200.00	70.60
August	105.00	170.00	375.00		105.00	187.00	70.00
September	110.00	164.00	360.00		100.00	170.00	65.80
October	105.00	160.00	300.00		105.00	160.00	63.00
November	100.00	155.00	250.00		112.50	155.00	61.50
December	100.00	162.50	245.00		123.08	125.00	60.00
Average	99.67	161.37	309.17	250.00	132.16	172.33	79.53

Manganese Deposits in the United States

In 1917 and 1918 there was a shortage of manganese ore in the United States owing to the impossibility of obtaining shipments from abroad. Because of the necessity of discovering further domestic supplies a group of ten geologists of the United States Geological Survey made a careful examination of districts throughout the country in which manganese ore was known or supposed to be present. The results of these examinations have been published by the Geological Survey and reviewed in Mineral Industry, including reports that describe the deposits in most of Virginia, Tennessee, Georgia, Arkansas, Oklahoma, Colorado, Wyoming, New Mexico, Arizona, Nevada, and southern California. One of the last of these reports describes the deposits of Montana, Utah, Oregon, and Washington.[1]

The deposits in Montana include those near Philipsburg, where 21 mines have been operated; those near Butte, where a number of mines have been operated but only five have been productive; and those of 11 other districts. The most productive deposits in Utah are in the Little Grande district, Grand County, where 20 mines were operated, although those in the Tintic and Erickson districts also produced some ore. Many deposits in Oregon and Washington were explored during the war, but only a few were brought to the shipping stage. In Oregon 12 groups of deposits in the Lake Creek, Gold Hill, and Greenback districts, Jackson County, as well as scattered small deposits in three districts in Baker County, were explored. The principal deposits of Washington lie along the east side of the Olympic Mountains, in Mason and Jefferson counties, but small deposits are found in four other districts.

[1] U. S. Geol. Surv. "Deposits of Manganese Ore in Montana, Utah, Oregon, and Washington," by J. T. Pardee, *Bull.* 725-C.

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In these four States there are many deposits, and they include highly divergent types. Some of them resemble well-known deposits in other States; others appear to be unique. In some districts, such as the Philipsburg, in Montana, and the Little Grande, in Utah, highly reliable estimates of the reserves were made. In other districts, such as Butte, Mont., and the Olympic Mountains, Wash., the conclusion was reached that large but otherwise indeterminable reserves exist. The reserves of the Olympic Mountains include highly silicious material which can not yet be smelted with profit. The reserves of most of the remaining districts are either definitely small and negligible or are highly problematic.

MANGANESE AND MANGANIFEROUS ORE (EXCLUSIVE OF FLUXING ORE) SHIPPED FROM MINES IN THE UNITED STATES

(In long tons)

1921.

State.	Ore Containing 35 Per Cent. or More of Manganese.			Ore Containing 10 to 35 Per Cent. of Manganese.			Ore Containing 5 to 10 Per Cent. of Manganese.		
	Number of Shippers.	Quantity.	Value.	Number of Shippers.	Quantity.	Value.	Number of Shippers.	Quantity.	Value.
Arizona	2	328	(a)	.....	.....	.....	.....	.....	.....
Arkansas	3	728	$16,360	2	278	$3,683	.....	.....	.....
Colorado	1	490	(a)	1	924	(a)	.....	.....	.....
Georgia	.....	.....	.....	1	7,162	(a)	1	6,140	(a)
Michigan	.....	.....	.....	1	51	(a)	.....	.....	.....
Minnesota	.....	.....	.....	.....	.....	.....	2	56,530	(a)
Montana	3	11,129	444,981	.....	.....	.....	.....	.....	.....
Tennessee	1	139	3,396	1	24	257	.....	.....	.....
Virginia	4	717	15,549	.....	.....	.....	.....	.....	.....
Undistributed	.....	.....	14,811	.....	.....	38,815	.....	.....	$147,576
Total	14	13,531	$495,097	6	8,439	$42,755	3	62,670	$147,576

1920.

Alabama	3	57	$1,923	1	150	(a)	.....	.....	.....
Arizona	3	2,402	72,067	.....	.....	.....	.....	.....	.....
Arkansas	14	3,445	93,077	9	4,403	$38,919	1	147	$ 308
California	5	1,733	53,285	.....	.....	.....	.....	.....	.....
Colorado	3	3,643	52,545	3	11,056	100,808	.....	.....	.....
Georgia	1	341	9,512	2	4,989	(a)	1	1,086	(a)
Michigan	.....	.....	.....	1	23,832	(a)	1	29,541	(a)
Minnesota	.....	.....	.....	10	293,524	1,084,553	3	248,913	527,393
Montana	5	76,441	1,966,881	.....	.....	.....	.....	.....	.....
Nevada	5	1,240	21,673	.....	.....	.....	.....	.....	.....
New Mexico	6	2,053	32,107	4	19,259	97,531	.....	.....	.....
Tennessee	3	502	16,436	.....	.....	.....	.....	.....	.....
Utah	.....	.....	.....	1	66	(a)	.....	.....	.....
Virginia	7	2,523	73,929	.....	.....	.....	.....	.....	.....
Wyoming	1	40	2,800	.....	.....	.....	.....	.....	.....
Undistributed	.....	.....	.....	.....	.....	128,707	.....	.....	116,871
Total	56	94,420	$2,396,235	31	357,279	$1,450,518	6	279,687	$644,572

(a) Included under "Undistributed." Not at liberty to publish.

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MANGANIFEROUS SILVER ORE SHIPPED
(In long tons)

Year.	Arizona.	Colorado.		Nevada.	New Mexico.
		For Fluxing.	For Other Purposes.		
1913	.....	49,753	.....	.....	.....
1918	(a)10,854	24,931	99,110	80,096	475
1919	(a) 1,964	29,769	11,055	77,815	250
1920	(a) 345	34,670	11,056	95,142	541
1921	.....	10,819	924	14,871	300

(a) Ore containing more than 35 per cent. of manganese sent to makers of manganese alloys not included.

Manganese in Foreign Countries

Australia.—The most important manganese occurrences are in the Gladstone and Rockhampton districts, Queensland. The mine at Mt. Millar near the former town is by far the largest producer of manganese ore in the State. This mine contains three well-defined grades of ore. The first grade ranges from 50 to 52 per cent. manganese, the second from 47 to 50 per cent., and the third from 40 to 47 per cent. The ores are hard and only a very small per cent. is lost in handling. Practically all of this ore is consumed in England.

The output of manganese ore in Queensland in 1921 was 833 long tons, compared with 15 tons in 1920. Manganese ore was exported from Australia during 1921 to the amount of 16 tons, while the imports reached the large figure of 1503 tons.

Brazil.—The principal one of the Brazilian deposits, Morro de Mina, is now owned by the U. S. Steel Corporation, which requires in periods of industrial activity about 500,000 tons of manganese ore per annum for its own consumption, so that a large production from this mine is indicated for the future. The mine has been operated for 18 years. The property is practically a mountain of ore, and mining consists of dynamiting off the side of the hill and crushing the blocks into convenient size for handling. The ore contains from 48 to 50 per cent. manganese.

The following table shows the exports from Brazil for several years past.

Year.	Metric Tons.
1910	252,958
1911	173,941
1912	154,870
1913	122,300
1914	183,630
1915	288,671
1916	503,120
1917	532,855
1918	393,388
1919	205,725
1920	453,737

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Chile.—Years ago the numerous deposits of manganese in the Coquimbo and Atacama districts were important sources of the world's supply of the ore, but due to the competition from Brazil, the exploitation ceased entirely.

Since ocean freight-rates have declined Chilean manganese could be mined and shipped to the United States at a good profit. The cost of transporting the ore to the coast could be reduced by the railroads.

China.—A consular report from China states that a mining company there is prepared to supply metallurgical manganese ore to the extent of 40,000 tons per year and chemical ore in small quantities. The company proposes to guarantee the composition of the various grades.

Egypt.[1]—The manganiferous ore deposits of Egypt occur on the Sinai Peninsula, principally in the district around Lat. 29° North and Long. 32° 21′ East. This is 10 to 15 miles inland from the shores of the Gulf of Suez and the harbor of Abu Zenima.

The topography of this part of the country is a mass of hills and ravines formed by the erosion of a plateau 2000 ft. above sea-level.

The ore-bearing rocks belong to the Carboniferous series, which here consists of two sandstones divided by a bed of limestone or dolomite. These Carboniferous rocks lie unconformably on the eroded surface of ancient schist, gneiss and granite. The formation has undergone considerable faulting which has a direct bearing on the occurrence of the manganese and iron ores found at the junction of the limestone and the lower sandstone. These ores exist both as pockets and as a horizontal bed varying from a few inches to several feet in thickness.

Mining facilities in the Sinai Peninsula are not unfavorable when compared with other parts of the world. Adequate labor can be obtained and its cost is reasonable. Water is scarce, but can be shipped economically from Suez.

The Sinai Mining Co. is the only operator which has yet reached the productive stage. Its mines are connected with the seaboard by 6 miles of aerial ropeway and 11 miles of railway which terminates at the harbor of Abu Zenima, where storage ore-bins and mechanical loading facilities have been installed.

The ore varies from a pure manganese to an almost pure iron ore, the bulk forming a manganese-iron ore averaging: Manganese 35.0 per cent., iron 23.0 per cent., silica 2.95 per cent. and phosphorus 0.136 per cent. Higher grades can be obtained by selection and recent shipments have assayed 40.41 per cent. manganese and 16.31 per cent. iron.

The production for the year 1921 was 55,065 metric tons, all of which was exported to Europe.

[1] Dept. of Mines, Egypt.

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Germany.[1]—Efforts of the Germans to procure high-grade manganese ore from foreign countries during the war had very little success. The main sources of supply before the war were Russia (from which nearly 400,000 tons was imported in 1913), British India, Spain and Brazil. All those supplies stopped at the beginning of the war. Small quantities of manganese ore were then imported from Sweden, but this was entirely insufficient.

For this reason steel production was dependent almost entirely upon reserves of manganese already accumulated in the country. Greatest economy was required, and therefore the available foreign ore was mixed with German ore. Increased production of the latter was taken energetically in hand. The main deposit to draw from was the hematite of the Lahn Valley, but even the iron ore in the Sieg district, containing a small percentage of manganese, was largely used by steel works.

Apart from this, ferromanganese was made from the so-called Siegerland slag, from blast-furnaces smelting Sieg ore, a slag containing from 8 to 9 per cent. of manganese. Vast supplies of this cinder, sufficient for many years, were available. This ferromanganese was called "Siegerland chip steel," and was produced by the blast-furnaces being burdened with two-fifths Siegerland slag and three-fifths iron scrap or turnings. Slag obtained at the Austrian steel works in Donawitz was even better for such purposes.

All efforts to find a substitute for manganese for the deoxidation of steel proved futile. The industry so far succeeded, however, in adapting the deoxidation process to low-grade spiegels and ferros that they were able to produce satisfactory results with the means at their disposal. Good results were obtained by using the deoxidation agent in liquid state. It should be mentioned that ferro-aluminium, containing from 15 to 20 per cent. aluminium, was used during the war for a deoxidizer.

Since the war the importation of manganese ore has again been resumed, but the main sources of pre-war supply are not drawn upon, Sweden and Spain now furnishing most of the tonnage. These imports are in no way equal to the pre-war imports, no doubt due to the considerably reduced steel production, but also to the fact that the experience gained during the war has made Germany's steel industry less dependent upon foreign manganese ore.

Great Britain.—This country produces a small quantity of very high-grade ore, but only a small fractional part of its domestic consumption. It is a very large importer to supply its steel industry, consuming most of the Indian output as well as large supplies from other sources.

[1] *Chem. Met. Eng.*, Mar. 22, 1922.

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BRITISH IMPORTS OF MANGANESE ORE IN LONG TONS

	Total.	Average per Month.
1913	601,177	50,098
1914	479,435	39,953
1915	377,324	31,443
1916	439,509	36,625
1917	331,264	27,605
1918	365,606	30,467
1919	265,800	22,150
1920	452,613	37,718
1921	172,856	14,405

It is reported that a promising prospect for manganese ore has been discovered and is being opened in the Culloden district of Wales. So far the work has not gone to a sufficient depth to demonstrate the commercial importance of the deposit, but it is believed from preliminary observations that the supply will be of considerable importance to the steel-making centers in that part of the United Kingdom.[1]

Hungary.—Important deposits of manganese have been discovered 15 miles north of Plattensee, in west Hungary. The main deposits are primary, while the less important ones are secondary. The ore varies in size from small grains to nodules weighing 20 to 40 lb. and in some cases blocks of from 170 to 250 lb. The area so far explored is estimated to contain half a million tons. The ore runs from 42 to 52 per cent. manganese.

India.—During the period of 1908 to 1912 no less than 28 per cent. of the total world's production of manganese came from India. The output in 1914 was over 500,000 tons, but the following year this was considerably reduced on account of the difficulties connected with the war. The decrease was nearly 34 per cent., but since that time there has been a steady increase in the output of the Indian mines, and there is every reason to believe that they will be worked to their full capacity in the near future.

Russia.—At the present time the mining of manganese is in a state of stagnation, although there are signs of resumption of activity in a small way. For many years prior to 1914 Russia was by far the greatest producer of high-grade manganese ore, averaging for a number of years over half a million tons per year. The ore runs from 53 to 54 per cent. manganese and is low in silica and phosphorus. Conservative engineers estimate the reserves at 100,000,000 tons. The area covered by the mines is about 55 square miles.

The shipments of manganese ore from the Caucasus, for a long time discontinued, were resumed during the latter part of 1921 from stocks existing at Poti. In spite of the difficulties of transporting the ore from the mining center in Tchiatouri, there existed at Poti at the end of 1921 about 8,000,000 poods, or 130,000 tons, of the ore ready for sale. It is said that 1,000,000 tons more is in stock at the mines.[2]

[1] *Comm. Rept.*, Apr. 17, 1922.
[2] *Echo des Mines et de la Metallurgie*, Apr. 1, 1922.

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It is known that in July, 1919, the Government of Georgia authorized the organization of a company for the sale of Caucasian ore, called the Société d'Exportation de Manganèse de Tchiatouri, which embraced under its control 27 companies of various nationalities, and representing 38 per cent. of the production of the mines. This company pays an export duty to the Government of Georgia and has a monopoly on the exportation of manganese ore and dioxide.

There has been practically no new mining of manganese in Transcaucasia during the past few years, partly because of difficulty with labor, but more particularly because of the general political and economic situation. Mine owners have not felt inclined to invest money with little possibility of being able to profit or even to reimburse themselves from sale of the product.

The export organization referred to above is now known as the "Temo" Export Manganese Co. It has sold considerable ore and claims to have large reserves available.

WORLD'S PRODUCTION OF MANGANESE ORE (a)
(In metric tons)

Year.	Austria-Hungary.	Belgium.	Bosnia. (b)	Brasil. (d)	Canada.	Chile. (d)	Cuba.	France.	Germany.	Greece.	India.
1907	24,954	2,100	7,000	236,778	1	(c)	30,486	18,200	74,683	10,000	916,770
1908	27,257	7,130	6,000	166,122	*Nil.*	1	1,492	15,865	67,092	10,750	685,135
1909	29,966	6,270	5,000	240,774	*Nil.*	(c)	2,976	9,378	77,177	5,374	654,974
1910	28,964	*Nil.*	4,000	253,953	*Nil.*	(c)	6,393	7,925	80,559	41	813,761
1911	30,713	*Nil.*	3,600	213,000	5	(c)	10,324	6,036	87,297	723	681,018
1912	23,306	*Nil.*	4,650	154,870	68	(c)	10,807	5,576	92,474	7,719	643,305
1913	35,549	*Nil.*	4,700	122,300	*Nil.*	(c)	11,589	7,732	330,797	556	528,089
1914	(f)11,413	*Nil.*	4,120	183,630	25	(c)	9,871	6,393	(c)	558	693,524
1915	(c)	500	10,422	288,671	182	(c)	9,145	10,324	(c)	408	457,668
1916	(c)	3,870	22,674	503,130	868	(c)	33,653	10,807	(c)	3,600	655,592
1917	(f)90,629	2,020	48,851	532,855	143	205	(d)45,223	11,589	(c)	*Nil.*	600,325
1918	(c)	2,610	(c)	393,388	399	3,046	(d)183,305	9,871	(c)	(c)	526,231
1919	(c)	*Nil.*	(c)	205,725	600	448	(c)	4,815	(c)	(c)	546 557
1920	(c)	*Nil.*	(c)	453,737	588	(c)	(c)	5,697	(c)	(c)	748,296

Year.	Italy.	Japan.	New Zealand.	Portugal.	Queensland.	Russia.	Spain.	Sweden.	United Kingdom.	United States.
1907..	3,654	20,589	26	1,374	1,134	995,282	41,504	4,334	16,356	5,694
1908..	2,750	11,130	*Nil.*	.....	1,403	362,303	16,945	4,616	6,409	6,243
1909..	4,700	8,708	6	.....	613	574,938	7,827	5,212	2,812	1,614
1910..	4,200	11,120	5	.....	805	(d)668,050	8,607	5,752	5,554	2,294
1911..	3,515	9,787	1	6	1,000	(d)584,000	5,607	5,377	5,067	2,497
1912..	2,641	12,060	*Nil.*	6	313	(d)766,000	19,936	5,101	4,237	1,691
1913..	1,622	2,313	*Nil.*	*Nil.*	27	1,171,000	21,594	4,001	5,480	4,113
1914..	1,649	17,076	*Nil.*	*Nil.*	6	737,300	(c)	3,643	3,496	2,677
1915..	12,577	25,870	*Nil.*	(c)	203	(g) 31,980	14,328	7,607	4,716	9,767
1916..	18,147	7,874	*Nil.*	(c)	653	(g)120,000	14,178	8,894	5,223	31,978
1917..	24,532	51,366	*Nil.*	(c)	21	(c)	57,474	19,873	10,104	131,475
1918..	31,896	29,759	*Nil.*	(c)	1,320	(c)	77,714	16,570	17,737	310,763
1920..	30,841	22,877	*Nil.*	(c)	20	(c)	66,685	12,278	12,272	55,839
1919..	36,158	(c)	2	(c)	15	(c)	21,256	14,926	13,082	95,940

(a) Official statistics. (b) Includes Herzegovina. (c) Statistics not available. (d) Exports. (e) Estimated. (f) Hungary. (g) Shipments from Tchiaturi district; mostly held at port for lack of shipping.

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Spain.—Manganese occurs in seven of the provinces of Spain. The annual production exceeded 100,000 tons during the period 1897–1900, but declined to 17,120 tons in 1912. As a result of new discoveries and more intensive work during the war period the yearly output has shown a considerable increase since 1916.

In 1919 the production was 66,685 metric tons, as compared with 77,714 tons in 1918, although the mines in the Province of Huelva, where almost all of the manganese is produced in Spain, increased their production from 51,354 tons in 1918 to 65,039 tons in 1919. The decrease in total was especially due to the non-production of a mine in the Province of Seville and another in the Province of Ciudad Real. The mines producing manganese numbered 32 in 1919, as compared with 34 in 1918.

Spanish manganese ore is commonly sold on the basis of its percentage content of manganese dioxide. In addition to the high-grade ore production, the same districts produce large quantities of manganiferous iron ore containing from 10 to 20 per cent. manganese and 20 to 25 per cent. iron. Most of the production goes to England, but since the war much is being sent to Germany.

Uses of Manganese

Probably about 95 per cent. of the world's production of manganese ores, manganiferous iron ores (using the term broadly), and manganiferous zinc residuum is used directly or indirectly in the manufacture of iron and steel, the small percentage of true manganese ore not so consumed being used elsewhere. The greater part of the ore used in metallurgy is consumed in the making of the ferro-alloys required for steel production (ferromanganese, spiegeleisen, silico-manganese, and silico-spiegel); the remainder—consisting wholly of manganiferous iron-ore—is used for the direct production of manganiferous pig iron. Self-hardening steels, made before the development of high-speed tool steels, contained from 3½ to 4 per cent. manganese. Nickel steels containing from 20 to 52 per cent. nickel and 5 to 6 per cent. manganese have been largely used, for many years, for electrical resistance-wires. The quantity of manganese consumed in the manufacture of manganese bronze, silver bronze, and other special alloys is relatively unimportant. The manganese bronze of commerce contains traces of manganese. The higher grades contain not more than 0.05 per cent. manganese. The principal function of manganese in the ferromanganese, or (as perhaps more usual in modern practice) the cupro-manganese added to the copper-zinc alloy, is to act as a deoxidizer. When ferromanganese is employed, the small amount of

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iron thus introduced into the bronze is stated to increase appreciably the strength and toughness of the alloy, the most important use of which is in the manufacture of steamship propeller blades. Manganese dioxide is extensively used in the manufacture of dry-cell electric batteries, and for decolorizing glass—to which a slight amount of iron in the form of ferrous silicate gives a green tint. For decolorizing glass, from 2 to 15 lb. of manganese ore, of about the same high grade as that for dry-cell manufacture, is required per 1000 lb. of sand, a larger addition resulting in an amethyst tinge; if as much as 30 lb. be added, a black glass is produced. Manganese dioxide and salts prepared therefrom are extensively used as driers of paints in linseed or other drying oils, the quantity added to the oil being usually less than 0.5 per cent. The dioxide is also employed in the manufacture of manganates and permanganates of sodium and potassium, used as disinfectants, for purifying various gases, and for other purposes. It has been extensively used in the manufacture of chlorine, but this gas is now obtained in the United Kingdom, the United States, and other large chlorine-producing countries almost entirely by electrolysis of either chloride of sodium or chloride of potassium. The dioxide is still used in some laboratories for the production of oxygen on a small scale. Manganese compounds are used to color glass, pottery, tiles, and bricks, in calico-printing and dyeing, and for certain paints (brown, green, and violet). Certain manganiferous ores from the weathered parts of silver-lead deposits are used as a flux in smelting lead and silver ores.[1]

[1] Imp. Min. Res. Bureau, London; abstract in *Min. Sci. Press.*

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MICA

By J. Volney Lewis

The mica industry in 1921 on the whole reflected the general depression of business all over the country. The decrease in the domestic output, sales, and prices, is marked and is not balanced by an increase in the imports. Several mica companies, especially in the South, were idle the entire year, and one large company discontinued business entirely.

Preliminary figures showing the quantity and value of mica sold in the United States in 1921, as reported by the United States Geological Survey, give a total of 3854 short tons, valued at $174,838. Of this quantity 371 tons (741,190 lb.), valued at $117,989, was sheet mica; the rest was scrap mica. These figures are obtained from reports received by the Geological Survey from 97 per cent. of the producers and others engaged in the mica business.

The production was made by eight States—North Carolina, New Hampshire, Virginia, New Mexico, Georgia, South Dakota, Colorado, and Wisconsin, named in order of total value of mica sold from greatest to least.

The total quantity of uncut sheet mica sold in 1921 shows a decrease of about 56 per cent. and the value a decrease of about 78 per cent.; scrap mica showed decreases of about 39 per cent. in quantity and of about 66 per cent. in value, as compared with 1920. Comparisons can not strictly be made with any year previous to 1920, as the figures for those years include cut mica, or mica that has been through several stages of preparation for the market and thereby commands a higher price than uncut mica.

The most notable decrease is shown by North Carolina, where sales of uncut sheet mica dropped about 79 per cent. in quantity and about 77 per cent. in value in 1921, as compared with 1920.

On the other hand, New Hampshire shows an increase in output of sheet mica of about 73 per cent. in quantity, but a decrease of about 25 per cent. in value. The increase in quantity is due to the larger production of mica of small size, such as punch and washer mica, which has had the effect of lowering the average price per pound of sheet mica in New Hampshire from 29 cts. in 1920 to 13 cts. in 1921. Scrap mica sold in this State in 1921 was 537 tons valued at $10,613, as against 435 tons valued at $12,877 in 1920.

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Market[1]

The mica industry at present is at its lowest point for many years. Large quantities of imported mica on hand are slowly being disposed of, while very few of the domestic mines are producing any mica of consequence. Probably only 10 per cent. of the firms producing in pre-war times are now operating.

This critical situation in the industry will remain until manufacturers using mica are working on a full-time basis, and domestic mica is again produced in such quality and quantity and at such price as to make it profitable for the consumer to use it.

The Fordney Bill proposes a tariff of 6 cts. per lb. on imported mica.

Prices.—The price of raw mica held fairly firm throughout the first half of 1921, but during the second half it dropped approximately 25 per cent. on the average for the different grades. For example, the No. A1 Clear India, which was sold around $5 per lb., f.o.b. New York, in case lots during the first half of the year, dropped to about $4 per lb.; No. 6 Clear India dropped from about 60 cts. per lb. to about 28 cts. per lb. in case lots. The principal demand was for No. A1, No. 1, No. 2 and No. 3. Sales are made through jobbers. Domestic production provides for much less than one-half of the country's requirements. The electrical manufacturers consume approximately 80 per cent. of the total of sheet mica used, the remainder going chiefly to the stove manufacturers.

Scrap mica was quoted in the beginning of 1921 about $24 per ton, and at the close around $20, f.o.b. mines, in carload lots. The decrease in sales during 1921 is roughly estimated at 50 per cent., with no tendency toward improvement at the end of the year. The largest consumers were buying from hand to mouth at the close of 1921, as compared with a willingness to contract ahead during the first quarter. The average price per pound of all sheet mica sold in the United States in 1921 was 16 cts., as compared with 32 cts. in 1920, and the average value per ton of scrap mica fell from $29 in 1920 to $16 in 1921.

Imports and Exports

The consumption of mica in the United States depends largely on the available quantity of foreign mica, the importations of which showed a notable decrease. The cut mica and splittings imported for consumption —and the splittings form the greater part of the imports—fell in value from $2,011,434 in 1920 to $758,521 in 1921. The unmanufactured mica, consisting essentially of uncut trimmed sheets, dropped in quantity from 1,298,537 lb. in 1920 to 328,444 lb. in 1921, and in value from $1,177,943 in 1920 to $331,219 in 1921.

[1] *Eng. Min. Jour.*, Jan. 21, Feb. 11, 1922.

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Mica exported from the United States is chiefly in manufactured form. This country is by far the largest consumer of mica, and the value of the exports in 1921 was only about 14 per cent. of the value of the imports, although in the case of imports the major portion is the unmanufactured and therefore lower-valued form. The value of the mica exports in 1921 was $153,990, compared with $316,169 in 1920.

UNITED STATES STATISTICS

PRODUCTION OF MICA IN THE UNITED STATES (*a*)

	Sheet Mica.		Scrap Mica.		Total Value.	Value of Imports.
	Pounds.	Value.	Short Tons.	Value.		
1911	1,887,201	$310,257	3,512	$45,550	$355,804	$505,552
1912	845,483	282,823	3,226	49,073	331,896	755,584
1913	1,700,677	353,517	5,322	82,543	436,060	947,780
1914	556,933	278,540	3,730	51,416	329,956	629,484
1915	553,821	378,259	3,959	50,510	428,769	692,269
1916	865,863	524,485	4,433	69,906	594,391	1,071,356
1917	1,216,816	708,381	3,250	48,965	757,346	1,430,048
1918	1,644,200	731,810	2,292	33,130	764,940	1,541,129
1919	1,545,709	483,567	3,258	58,084	541,651	1,632,893
1920(*b*)	1,683,480	546,972	5,723	167,017	713,989	3,476,307
1921(*b*)	741,190	117,989	3,483	57,849	174,838	1,180,119

(*a*) U. S. Geol. Surv. (*b*) The figures for quantity and value of sheet mica are not strictly comparable with those of any previous year, for the reason that they represent uncut sheet mica exclusively. In previous years the totals have included some cut sheet mica, and the cutting has the twofold effect of reducing the quantity and of increasing the value.

IMPORTS OF MICA INTO THE UNITED STATES[1]

	Unmanufactured.[4]		Cut, Split, and Mfd.[5]		Ground.		Total.
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Value.
1911	1,087,644	$346,477	241,124	$155,686	.....	$3,389	$505,552
1912	1,900,500	649,236	88,632	99,737	.....	6,611	755,584
1913	2,047,571	751,091	46,336[2]	191,924	290,757	4,765	947,780
1914	360,888	168,591	.....[3]	456,805	404,840	4,088	629,484
1915	433,822	240,449	.....	447,962	344,040	3,858	692,269
1916	703,832	421,856	.....	646,080	362,000	3,420	1,071,356
1917	656,391	414,823	.....	1,014,181	92,963	1,044	1,430,048
1918	741,429	658,576	.....	880,906	11,587	1,647	1,541,129
1919	877,592	889,538	.....	743,346	62	9	1,632,893
1920	1,447,208	1,298,342	.....	2,176,210	760	1,755	3,476,307
1921	466,513	389,258	.....	790,861	.....	.....	1,180,119

[1] Statistics from Bureau of Foreign and Domestic Commerce.
[2] From Jan. 1 to Oct. 3.
[3] Quantities not reported.
[4] Essentially trimmed sheets.
[5] Includes Madras square-shaped uncut sheets.

EXPORTS OF MICA FROM THE UNITED STATES

(Bureau of Foreign and Domestic Commerce)

	Unmanufactured.		Manufactured.	Total.
	Pounds.	Value.	Value.	Value.
1913	298,711	$14,175	$62,184	$76,359
1914	467,451	23,145	50,896	74,041
1915	54,183	5,118	39,033	44,151
1916	63,168	4,544	78,671	83,215
1917	.....	.....	.....	74,485
1918	.....	.....	.....	74,529
1919	.....	.....	.....	109,848
1920	.....	.....	.....	316,169
1921	.....	.....	.....	153,990

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World's Sources of Mica

The world's production of sheet mica approximates 3000 tons annually, of which the United States consumes roughly one-half, but produces less than one-fourth. India has always been the chief source of the world's supply, with Canada and the United States next in rank. Recently many other countries have become producers or extended their previously small outputs, but none approaches the above three countries in importance. These minor sources include Brazil, Argentina, Chile, Costa Rica, and Peru in South America; Guatemala and Mexico in North America; Rhodesia, Union of South Africa, Southwest Africa, and Madagascar in Africa; Ceylon, China, Japan, Korea, and Siberia in Asia; Norway in Europe; and Australia and New Zealand. The mineral is therefore widely distributed, but in most of these countries the deposits are small and of lower quality than those of the three principal producers.

Argentina.—Mica has been mined on a small scale in Argentina for many years, but it is only recently that the industry has received serious attention. Formerly the mica obtained was mostly sent to Great Britain, but since the extension of the industry most of the exports go to the United States. Some is manufactured in Buenos Aires.

The mica exported is muscovite, from the pegmatites of the sierras of Cordoba and San Luis, occurring throughout the extent of the Cordoba hills and northward through the provinces of Catamarca, La Rioja, Tucuman, and the territory of Los Andes. All of the mining is done on a small scale by individuals with little or no capital, and the mica is sold to factories or dealers in Buenos Aires. The chief local use is in the manufacture of electrical heaters, although one small factory in Buenos Aires selects and cuts mica for phonograph discs and other uses. There are, however, no figures available on the production of mica for domestic consumption. According to one mine owner, a metric ton of mica from the Cordoba mines will yield sizes as follows: Special, 15 kilos; No. 1A, 35 kilos; No. 1, 50 kilos; and in increasing proportion through the following five grades to 300 kilos of No. 6.

According to the Argentine mining code, it is not necessary to own land in order to exploit the mica, mining rights being taken out by anyone who locates the mineral; therefore American companies interested will not find it necessary to own mines. The numerous known deposits of the Cordoba hills, 200 miles west of the port of Rosario, are capable of being put on a producing basis if payment for the mineral can be made at the mine or railroad station. Lack of capital is holding back the workings. An American company well represented in the field could collect almost any desired quantity of Argentine mica for export.[1]

[1] *Comm. Rept.*

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In the five years preceding the war 46 tons of mica was exported. The following figures give the exports for the last six years:

	Metric Tons.	Value.
1916	5	$3,747
1917	70	35,209
1918	214	177,732
1919	145	.....
1920	193	261,158
1921	25	51,182

Austria.[1]—Mica deposits in Western Styria recently formed the subject of a lecture before the Vienna Geological Society, at which samples were exhibited as proof of fine quality. Experiments made with the mica were satisfactory, and as the deposits are extensive and easily accessible, it is hoped that the whole of the Austrian requirements, and perhaps those of Germany as well, may sometime be supplied from this source. Further information can be obtained from the Austrian Trade Museum, at Vienna.

Brazil.—Mica is becoming an important article of export in Brazil. The Brazilian mica is muscovite, of excellent quality, the masses taken out for export being mostly about 6 in. square, although much larger are often found. Production has so far been confined to four states, Bahia, São Paulo, Goyaz and Minas Geraes.

From 1902 to 1913 Brazil produced about 113 short tons of mica; in 1916, 59 tons; in 1917, 106 tons; in 1918 and 1919, estimated at 135 tons yearly. The State of São Paulo has exported mica as follows:

	Kilos.	Value, Paper Milreis.
1914	400	800,000
1915	19,183	22,520,000
1916	7,574	13,220,000
1917	10,771	63,664,000
1918	11,604	57,240,000

Canada.[2]—Canadian phlogopite continues to supply most of the world's "amber mica," which is preferred for certain electrical uses. The mica occurs in dike-like bodies that are structurally somewhat similar to pegmatites. The chief associated minerals are pyroxene, apatite, and calcite, although in some deposits the mass is almost entirely mica. The enclosing rock is commonly limestone.

Practically the same amount of mica was marketed in 1921 as in the preceding year, the total being in the neighborhood of 700 short tons. The mica sold by the 20 firms producing during the year was valued at $76,773. The principal producing province was Quebec, in which 14 operators worked during the year. Only six firms in Ontario reported production. In Quebec the production in 1921 was valued at $41,092.

[1] *Min. Jour.*, May 14, 1921.
[2] Prelim. Rept. Min. Prod. of Canada, Dominion Bur. of Statistics.

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This is a decrease of 85 per cent. as compared with 1920 when the value totaled $281,729, and it is the smallest production of mica since the year 1902, when it was $34,304.

The occurrence of workable deposits of mica is reported from the neighborhood of Neils Harbor, in northern Cape Breton Island, associated with feldspar and white quartz. Negotiations for sale are stated to be under way.[1]

In the period 1906 to 1917 Canada furnished approximately 11 per cent. of the world's supply of mica.

STATISTICS OF MICA IN CANADA

	Production.		Exports.	
	Short Tons.	Value.	Pounds.	Value.
1913	.....	$194,304	817,152	$240,775
1914	.....	109,061	669,163	178,940
1915	.....	91,905	879,631	236,124
1916	.....	122,541	1,308,793	379,720
1917	.....	218,034	1,198,707	456,671
1918	747	271,550	866,000	410,000
1919	2,754	273,788	5,482,000	641,962
1920	2,203	376,022	6,606,000	815,633
1921	706	76,773	2,228,000	220,482

Guatemala.—The Guatemalan mica is of the muscovite variety, various colors being found. Most of the shipments have not been of a satisfactory quality, splitting badly and proving unsuitable for electrical purposes. However, some recent development in the Department of Quiche has yielded mica of better grade and running to larger sizes. The cost of production of Guatemalan mica is very high, and on account of unfavorable mining conditions with respect to occurrence, scarcity of labor, and poor transportation facilities, there is little prospect for an increase in output in the near future.

In 1919 the exports of mica from Guatemala to the United States amounted to 24,391 lb. valued at $9601, while in 1920 the amount was only 1146 lb. valued at $168.

India.[2]—The mica industry in India originated several centuries ago, and there are at the present time over 15,000 men, women and children employed in mica mining and handling.

The continuous and steady growth of the industry in India has been due to the facts that from its long and regular period of operation, the difficulties and obstacles in the way of successful mica mining are there better understood and more competently dealt with, and low-cost labor is abundant, satisfactory, and sufficiently skilled. Furthermore the necessary processes of preparing and grading mica stocks prior to ship-

[1] *Can. Min. Jour.*, Aug. 19, 1921.
[2] Geol. Surv. of Alabama, Bull. No. 24 (1921).

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ment are properly emphasized—a vital condition for successful operation, singularly lacking in very many attempted mica recoveries elsewhere.

Beginning with the first reliably recorded output in 1890, of 346 short tons, the average annual production from 1901 to 1917 was 1823 short tons, reaching the maximum of 2579 short tons in 1918, coming largely from the Bihar and Orissa fields. During the above defined period, India furnished over 60 per cent. of the world's sheet mica, amounting to practically three-fourths of the world's sheet muscovite. The average labor cost for men, women and children in the East Indian mica district averages less than 30 cts. per day, and the product of this field, re-shipped from England, has benefitted by the further advantage of favorable exchange rates. Of the total sheet-mica output, Bengal has supplied about three-fourths, the remainder having been drawn from Madras, with the exception of very small amounts from Rajputana.

Systematic study given to the mica industry by the India Geological Survey during the war, with a view to pointing out and opening up new occurrences, and to the re-working of the old mines by new and more efficient methods, tends to show that the future of mica mining in India is very promising, and would indicate that if the present preferential conditions as to mine cost and available markets continue, India may easily maintain its present lead in production.

The Indian mica production in 1920 is reported as 2348 long tons, valued at £235,078, against 2289 tons valued at £219,843 in 1919. These figures are given by the Geological Survey of India, but with the statement that they are not very reliable. It is noted that the exports always exceed the reported production. Exports in 1920 were 3826 long tons, and in 1919 2955 tons.

Norway.[1]—Before the European War the greater part of the Norwegian demand for mica was covered by Norwegian production. During the war this industry grew very fast, and considerable quantities of mica were exported. At present the production is small, on account of the high working expenses, but when normal times return the mica industry will become important. The feldspar mines produce much mica scrap.

Queensland.[2]—A valuable find of mica is reported at Lagoon Creek, near Camooweal. Samples were sent to the Government assay office at Cloncurry, which reported that for certain classes of manufacture the quality was very good. It will not be suitable for the electrical trade, but for manufacture the quality is as good as that produced in any other part of the world. Australia consumes only a very small quantity, but mica of this quality could be shipped profitably to overseas markets. Very good mica has in the past left Australia for overseas markets, and

[1] *Comm. Rept.*, May 23, 1921.

[2] *Queens. Govt. Min. Jour.*, Sept. 15, 1921.

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has been a failure because of faulty classification. In one instance, only 2s. or 3s. per cwt. was received for mica, some of which, if classified properly, would have brought as much as 30s. per lb.

Bibliography

In addition to the annual reports of the U. S. Geological Survey, there appeared in 1921 two other extensive reports on the mica industry.

The first of these is one of a series of pamphlets on the Mineral Industry of the British Empire and Foreign Countries during the war period (1913–1919), by the Imperial Mineral Resources Bureau, London.

The second is entitled "Mica Deposits of Alabama," by George H. Clark, Bulletin No. 24, Geological Survey of Alabama. The first part of this report is a general review of the world's mica industry, while the second part describes the Alabama deposits in minute detail.

"Geology and Mining of Mica", by J. Volney Lewis, was published in the *Engineering and Mining Journal-Press*, May 20, 1922, pp. 856–864.

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MOLYBDENUM

By W. Norman Bratton

During 1921 the developments in connection with molybdenum were very marked, exceeding any previous year, and reached into fields where there was no previous thought of its application.

The tonnages of molybdenum steels in the United States are now an appreciable percentage of the alloy-steel total and this percentage is mounting rapidly.

In the search for better and cheaper materials, molybdenum has stood the test and gained an increased prestige. The work done still further confirmed the quality and economy of molybdenum steels and enlarged the outlook for the future.

Merchandising in 1921

In the United States the sale of molybdenum is not purely a brokerage transaction. The producing companies are working hand in hand with the consumers in well-organized technical and sales co-operation.

The consumption of molybdenum steel in the automotive industry is a good quota of the total tonnage. Accordingly the stocks of molybdenum steels at the mills are quite varied and cover a large range of miscellaneous requirements. At the steel mills, however, there is enough molybdenum on hand, left over from the war, to last for a long time.

Tariff.—Molybdenum was included in a bill before the Congress of the United States for an import duty on molybdenum in molybdenum ore or concentrates and for molybdenum in alloys and compounds of molybdenum.

Price.—The price of molybdenite was not stabilized because of lots left over from the war which were sold at a valuation much less than the actual cost of present production. The high and the low showed very little variation for the year. Ferromolybdenum sold in the United States at $2.00 to $2.50 per lb. of molybdenum contained. Prices in England were nominal.

Metallurgical Status

Analyses, treatments, and physical properties of molybdenum steels are now standardized for a large variety of uses. The Standards Com-

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mittee of the Society of Automotive Engineers has reserved the 4000 series for molybdenum steel in their numerical system of designating steel.

A number of papers during the year gave the advantages of molybdenum steel in machining, forging, and heat-treatment, and the competitive cost for given physical properties. C. N. Dawe brought out the reasons for the adoption of chrome-molybdenum steel by the Studebaker Corporation and the excellence of nickel-molybdenum case-hardening steel.[1] Arthur H. Hunter summarized the manufacturing economies.[2]

Within the year there was a marked use of molybdenum in massive forgings and castings that were limited by size, shape, or equipment to the development of physical properties by cooling the steel in air, notably in steel and iron rolls.

In tool-steels molybdenum is used in advertised brands of shovels, riveting hammers, and twist-drills. In sheet steels molybdenum works into difficult shapes and welds easily, so that sheet-metal parts of intricate forms have a combination of lightness and strength which is especially desirable in automobiles. In non-ferrous alloys molybdenum has a pronounced effect in brasses and bronzes.

Molybdenum Mining

Australia.—Operations for the year were practically at a standstill.

Canada.—During the past two years several companies have been intermittently engaged in developing and prospecting their properties, among which are the Daley Molybdenite Co., Ltd., St. Maurice Mines Co., Ltd., L. N. Benjamin, and the American Molybdenites, Ltd. A few lots and samples from various properties were sent to the Mines Branch ore-testing laboratories for analysis and experiments on concentrating.[3]

Norway.—In 1920 there was some experimental mining at Laxadalen Molybdengruber, Nordland.[4]

No mines operated otherwise than experimentally in 1921.

United States.—There have been practically no molybdenum operations during the year 1921 outside of a few tests on concentration, which are more or less duplications of what have been done before.[5]

The 1000-ton mill of the Climax Molybdenum Co. was arranged to work at one-fifth capacity to treat 200 tons of ore a day. All structures and underground workings were maintained in readiness for projected operation.

1 "Chrome Molybdenum Steel Applications from the Consumer's Viewpoint."
2 "Molybdenum Steel."
3 Department of Mines.
4 Bureau Central de Statistique.
5 U. S. Bureau of Mines.

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A report of "Appraisal of Mining Properties of New Mexico" by J. R. Finlay for the State Tax Commission gives the following data on the molybdenum deposits of the Molybdenum Corporation of America near Questa, N. Mex.

"Operations thus far have been largely experimental. The principal ore-shoot has been opened up for a length of about 400 ft., and judging from exposures on the canyon wall, it will probably extend 100 ft. above the tunnel level. On a conservative estimate, it may contain 30,000 tons of 1-per cent. ore."

Molybdenum Tonnages

Australia.—Exports of molybdenite in 1921 were 20 long tons.

New South Wales.[1]—The output of molybdenite for the year 1920 was 40 long tons, valued at £8442, representing a decrease of £21,886 as compared with the previous year.

After the expiration of the contract between the Commonwealth and Imperial governments at the end of March, 1920, there was practically no sale for molybdenite, and production suffered in consequence.

The following table shows the quantity and value of molybdenite produced in New South Wales to the end of 1920:

Year.	Quantity, Long Tons.	Value, £.	Year.	Quantity, Long Tons.	Value, £.
To the end of 1910	572	£175,761	1916	54	£22,066
1911	21	2,591	1917	70	31,608
1912	56	3,706	1918	93	41,850
1913	79	6,802	1919	66	30,308
1914	61	11,451	1920	40	8,442
1915	32	16,937			
			Totals	799	£205,500

The production for 1921 amounted to one-half ton of concentrates.

South Australia.—The official report of the Department of Mines gives the molybdenum output as follows:

	Pounds.	Value.
1916	*Nil.*	*Nil.*
1917	2070	£359
1918	504	98
1919	392	70
1920	*Nil.*	*Nil.*
1921	*Nil.*	*Nil.*

Queensland.[2]—The production of molybdenite in Queensland in 1921 was 8 tons (long) 15 cwt., valued at £2187, all of which was obtained in the Chillagoe district. In 1920 the output was 28 tons 19 cwt., of which 5 tons came from the Mt. Perry district, 12 cwt. from the Star River (Ollera) district, and all the balance from the Chillagoe district.

[1] Dept. of Mines.
[2] *Queens. Govt. Min. Jour.*, April, 1922.

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As a consequence of the continued depression in the price of wolfram and molybdenite, all the centers productive of these minerals—Mount Carbine, Wolfram, Bamford, etc.—were practically idle throughout 1921. Some desultory productive work was done in the hope of a revival in the market, and also in the way of cleaning up of odd parcels and working places, but the majority of the former population has migrated to other mining districts or to fresh occupations in agricultural areas and southern centers of business. Many of the plants have been sold for removal or are being dismantled and sold piecemeal.

Victoria.[1]—The total quantity and value of molybdenite raised in Victoria to the end of 1920 was as follows:

Quantity raised during 1919, 78 long tons valued at £2531.
Quantity raised during 1920, 48¼ long tons valued at £1085.
Total to the end of 1920, 182 tons valued at £4296.

The production of molybdenite for 1919 and 1920 from the Standard Molybdenite mine at Egerton was 126¼ tons valued at £3616; for 1920 from Lease 3541, Korong Vale, 4 tons valued at £40.

Canada.[2]—There was no production of molybdenite in 1920, whereas in 1919 the production amounted to 83,002 lb., valued at $69,203, and in 1918 to 378,029 lb., valued at $434,733.

The exports of molybdenite in 1920 were 100 lb., valued at $75, as against 113,500 lb., valued at $84,226 in 1919, and 351,600 lb., valued at $402,435, in 1918.

Of the many producers of molybdenum who operated during the war none reported any production during 1921, and one property only reported doing a little development work. During the year a total of 1700 lb. of molybdenum was exported to the United States, this shipment being made from stocks left over from the previous years. The value of the shipment was $619.

CANADIAN MOLYBDENUM STATISTICS

	1916.	1917.	1918.	1919.
Ore mined, short tons	13,522	26,871	34,030	7,280
Ore treated, short tons	9,106	22,605	33,935	6,783
Ore or concentrates shipped, tons	610	1,554	461	46
Ore or concentrates shipped, value	$188,316	$320,006	$428,807	$69,203
MoS_2 content of shipment paid for, pounds	156,461	288,705	378,029	83,002
MoS_2 content of shipment paid for, value	$156,461	$288,705	$434,733	$69,203
Exports of molybdenite, pounds	(a)	(b)64,700	351,600	113,500
Exports of molybdenite, value	(a)	(b)81,173	$402,435	$84,226
Men employed	262	501	119	105
Wages paid	$122,072	$260,692	$274,945	$35,536

(a) No figures available for 1916. (b) Cover 9 months only.

England.—The United Kingdom imports of molybdenum ore during 1920 were 166 tons.

Norway[3]—There was no production during the year 1920 or 1921.

[1] Dept. of Mines.
[2] Dept. of Mines.
[3] Bureau Central de Statistique.

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There were, however, exports of molybdenum ore in 1921 amounting to 59 metric tons, compared with 78 tons in 1920 and only 1 ton in 1919. The molybdenum content is not stated.

Peru.[1]—The production of molybdenum in 1920, taking as production the amount exported, was 2415 kg. (5324 lb.) of concentrates, containing an average of 85.05 per cent. MoS_2. Thus the molybdenite content was 2054 kg. (4528 lb.); the value was £550 ($2676 at normal exchange). This production came from the provinces of Jauja and Cajatambo, in the departments of Junín and Lima, respectively.

PRODUCTION OF MOLYBDENUM IN PERU (a)

Year.	Concentrates, Kg.	MoS_2 Content.	Value.
1915	2,740	2,198	£1,435
1916	5,752	5,177	2,900
1917	7,017	5,845	4,309
1918	4,123	3,161	1,532
1919	4,740	4,027	1,194
1920	2,415	2,054	550

(a) *Estadistica Mineral del Peru.*

Sweden.[2]—The production of molybdenum ore in Sweden was only 600 kg. (1323 lb.) in 1920, and only 80 kg. (176 lb.) in 1919. The largest output was 137 metric tons, in 1917.

United States.[3]—From Jan. 1 to Mar. 31 there were imported into the United States 3375 lb. of molybdenum ore, valued at $2025, and 250 lb. of molybdenum metal and ferromolybdenum valued at $292; from July 1 to Sept. 30, molybdenum ore imports were 20,843 lb. valued at $7944; from Oct. 1 to Dec. 31, there were imported 5565 lb. of molybdenum ore valued at $10,502, and 95 lb. of molybdenum metal and ferromolybdenum valued at $57. These comprise the total receipts of molybdenum ore, molybdenum metal and ferromolybdenum entered for consumption into the United States during 1921.

MOLYBDENUM IN ORE AND CONCENTRATES PRODUCED AND SOLD IN THE UNITED STATES (a)

Year.	Quantity Sold (Pounds).	Value.	Year.	Quantity Sold (Pounds).	Value.
1914	1,297	$1,297	1918	861,637	$1,253,700
1915	181,769	114,866	1919	(b)	(b)
1916	206,740	205,000	1920	(b)	(b)
1917	350,200	495,350			

(a) U. S. Geol. Surv.
(b) Not at liberty to publish figures.
[1] *Estadistica Minera del Peru in* 1920.
[2] Bureau Central de Statistique
[3] Dept. of Commerce.

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ESTIMATED WORLD'S PRODUCTION OF MOLYBDENUM (a)
(In metric tons, Mo content)

	1916.	1917.	1918.	1919.	1920.	1921.
Australia, New South Whales	29	36	48	32	22	*Nil.*
Australia, Queensland	44	57	56	62	15	5
Australia, Victoria	.....	.....	3	43	23	.....
Canada	42	89	102	22	*Nil.*	*Nil.*
Japan	18	12	.....	.....	.....	.....
Korea	3	60	11	.....	.....	.....
Mexico	.....	.....	14	1	2	2
Norway	57	90	74	.....	*Nil.*	.....
Peru	3	4	2	2	1	.....
Spain	26	.....	.....	.....	.....	.....
Sweden	.....	22	25	*Nil.*	*Nil.*	.....
United States	93	159	391	.....	.....	.....

(a) Figures are stated in molybdenum content of ores or concentrates, calculated from official reports. Where given calculation is based on average Mo content as stated in these reports; when not given it has been necessary to estimate the Mo content. Some estimates are taken from the Canadian Dept. of Mines.

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MONAZITE

By Sydney J. Johnstone

During 1921 the monazite-consuming industries in several countries were in a somewhat unsettled condition owing to impending tariff changes, exchange fluctuations, and variations in demand for the finished products.

United States.—As in recent years, the monazite consumed in the United States was practically all imported from Travancore (Southern India) or from Brazil, the ouptut from domestic sources being negligible in amount.

MONAZITE PRODUCTION IN THE UNITED STATES

Year.	United States. (a)			North Carolina.		
	Pounds.	Value.	Per Pound.	Pounds.	Value.	Per Pound.
1909	541,931	$65,032	$0.120	(c)391,068	$46,928	0.120
1910	99,301	12,006	0.121	(b) 83,454	10,104	0.121
1911	3,561	427	0.120	400	48	0.120
1912	1,272	159	0.120	*Nil.*	.....	.....
1913	*Nil.*	.....	.....	*Nil.*	.....	.....
1914	*Nil.*	.....	.....	*Nil.*	.....	.....
1915	36,000	3,600	0.100	36,000	3,600	0.100
1916	37,872	3,400	0.090	37,872	3,400	0.090
1917	77,743	3,806	0.049	77,743	3,806	0.049
1918	*Nil.*	.....	.....	*Nil.*	.....	.....
1919	(d)	.....	.....	.....	.....	.....
1920	(d)	.....	.....	.....	.....	.....
1921	(d)	.....	.....	.....	.....	.....

(a) Statistics are those of the U. S. Geological Survey. (b) Statistics for 1910 furnished by Joseph Hyde Pratt, State Geologist. (c) Statistics for 1907, 1908, and 1909 were collected jointly by the U. S. Geological Survey and the N. C. Geological and Economic Survey.
(d) Only one producer; figures cannot be revealed.

IMPORTS OF MONAZITE SAND AND THORITE (a)
(In Pounds)

From.	1915.	1916.	1917.	1918.	1919.	1920.	1921.
Brazil	1,464,963	352,780	1,079,427	1,122,998	832,022	1,900,000	542,080
England	291,342	1,170,721	1,134,433	1,341,571	.....	.....	.....
Canada	2,500	.....	2,340	1,786,050	.....	238,096	(b)750
British India	.....	.....	.....	725,356	774,646	672,000	.....
Total	1,758,350	1,523,501	2,216,200	4,975,975	1,606,668	2,810,096	542,130

(a) Figures prior to 1919 are for the fiscal years ending June 30, those for 1919 onwards are for the new fiscal year ending Dec. 31. (b) Japan.

With the present state of the market, it is unlikely that the deposits of monazite sand in the United States can be extensively worked at a

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profit. So far as can be ascertained, the only deposit on which any work was done during 1921 was that in Florida controlled by Messrs. Buckman & Pritchard. It was announced by the Bureau of Mines that rich specimens of monazite had been examined from New Mexico, but details are not available as to the economic possibilities of the occurrence.

IMPORTS OF THORIUM NITRATE, THORIUM OXIDE AND MONAZITE (a)

	Year.	Pounds.	Value.	Per Pound.
Thorium nitrate entered for consumption.....	1913	112,105	$212,263	$1.89
	1914	101,927	239,376	2.35
	1915	67,406	169,617	2.52
	1916	909	3,884	4.27
	1917	1,188	2,359	1.98
	1918	*Nil.*	.....	.....
	1919	3,307	5,250	1.59
	1920	35,640	43,221	1.21
	1921	44,554	89,672	2.01
Thorium oxide and other salts entered for consumption..	1916	4,099	$9,487	$2.36
	1917	11	293	26.64
	1918	28	124	4.43
	1919	*Nil.*	.....	.....
	1920	*Nil.*	.....	.....
	1921	*Nil.*	.....	.....
Monazite sand (and thorite) entered for consumption...	1913	1,145,010	$94,425	$0.082
	1914	770,842	61,595	0.080
	1915	1,573,971	161,456	0.117
	1916	1,221,399	120,077	0.098
	1917	4,598,926	297,898	0.065
	1918	2,994,515	204,661	0.068
	1919	632,568	48,768	0.077
	1920	1,814,182	141,528	0.078
	1921	542,130	25,272	0.047

(a) Bureau of Statistics of the Department of Commerce.

The above figures show that the quantity of monazite sand imported in the United States during 1921 was less than one-third of the amount imported in 1920 and lower than in any year since 1912. On the other hand, the imports of thorium nitrate were the highest since 1915, but still amounted to less than 40 per cent. of the amount imported in 1913.

It is stated that the principal causes of the decline in the imports of monazite sand and production of thorium nitrate were foreign competition in thorium salts, principally from Germany and Great Britain, at unusually low prices, due to depreciated currencies, and a sharp decline in the demand for gas-mantles owing to the increased use of electric light.

During the year Indian and Brazilian monazite was sold at prices varying from £5 to £5.10 per unit of thoria, c.i.f. New York. These prices did not include the import duty of 25 per cent. *ad valorem*.

The principal producers of thorium nitrate in the United States during 1921 were the Lindsay Light Co. and the Welsbach Co., but it is stated that their combined production during the year required only about

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400 tons of monazite. At the end of the year both companies held good stocks of the sand in reserve.

The production of thorium nitrate from three other works which had previously made the salt was suspended during 1921, and the works were still out of operation during the early part of 1922.

During the early part of 1921 imported British and German thorium nitrate was sold at $6 per kilo (duty paid); later in the year the price had fallen to $5 per kilo. American-made thorium nitrate was quoted at $8.25 per kilo.

Thorium nitrate made in the United States is used almost entirely in the production of incandescent gas-mantles. The value of these goods exported during the years 1918 to 1921 amounted to $252,284, $358,642, $478,371, and $204,264, respectively.

India.—The beach-sand and dunes between Muttum and Colachel were worked by the two companies as in previous years.[1] The total production of high-grade monazite concentrates containing from 8.5 to to 9.5 per cent. of thoria is estimated to be about 1600 tons.

Ceylon.—The Government-operated plant at Bentota was working throughout the year producing high-grade concentrates carrying about 9 per cent. of thoria, but practically no monazite sand was exported from the Island during 1921.

Brazil.—During 1920 there was a revival in the monazite trade in Brazil owing chiefly to demands from the United States, but during 1921 the quantity exported showed a decrease.

The quantities (in metric tons) and destinations of the monazite sand exported from Brazil during recent years have been as follows:

Destination.	1914.	1915.	1916.	1917.	1918.	1919.	1920
Italy	.....	.....	.....	.....	.....	.....	95
France	.....	.....	.....	.....	.....	.....	.....
Germany	.....	.....	.....	.....	.....	.....	.....
United States	600	439	.....	.....	.....	146	1,058
Total	600	439	*Nil.*	1,136	499	146	1,153

Africa.—Acccording to the first annual report of the Government Geologist for Uganda, monazite is of wide distribution in the Protectorate, but there are only two localities in which it occurs in quantity. One of these is conveniently situated as regards transport and mining facilities.

France.—The consumption of monazite sand for the production of thorium nitrate and pyrophoric alloy remained much the same as in

[1] See MINERAL INDUSTRY, 29, 471 (1920).

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recent years, but cerium earth residues used in the manufacture of the latter substances were produced in France instead of being imported from the United States. Thorium nitrate was produced by two companies.

Germany.—Statistics are not available concerning the extent of Germany's trade in monazite sand or products made therefrom, but it is evident from her activity in foreign markets that the trade is in a very flourishing condition. This is possible owing to the depreciated value of her currency and the great difference between the internal and external value of the mark. The output of incandescent mantles during 1921 amounted to about 2,000,000 gross. An interesting account of the devices used in Germany during the war to alleviate the shortage of materials for the incandescent-mantle industry has been given by Dr. Geisel.[1] When war broke out the supplies of monazite sand in Germany were stated to be sufficient for 10 years' normal consumption, but the available supplies of ramie, artificial silk, and asbestos were very small. Paper fiber was used as a substitute for ramie, while iron wire replaced asbestos in some cases, but inverted mantles were fixed to the supporting rings by means of enamel. As supplies of collodien were not available the burnt-off mantles were made suitable for transport by being treated with phenol condensation products. As might be expected mantles produced from raw materials of this character had not the durability or lighting properties of those made under normal conditions.

Italy.—The consumption of monazite sand during 1921 was small owing to the depressed state of the incandescent-mantle trade in Italy. Formerly thorium nitrate was exported to the United Kingdom, but early in 1922 it was reported that the closing of the principal Italian thorium-nitrate factory was contemplated, as this export was no longer possible.

Great Britain.—During the year 1921 the thorium-nitrate and incandescent-mantle trades were in a very unsettled condition owing to German competition and uncertainty as to what would be the outcome of several appeals pending under the Safeguarding of Industries Act.

IMPORTS OF MONAZITE SAND INTO GREAT BRITAIN

Country Whence Consigned.	1917.	1918.	1919.	1920.		1921.	
	Value.	Value.	Value.	Tons.	Value.	Tons.	Value.
British India	£14,773	£8,065	£7,304	650	£13,435	700	£13,200
Ceylon			1,850	72	3,250	0.2	4
South America							

[1] *Chem. Zeit.*, Sept., 1921.

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IMPORTS OF THORIUM NITRATE INTO GREAT BRITAIN

Country Whence Consigned.	1920.		1921.	
	Quantity, Pounds.	Value.	Quantity, Pounds.	Value.
Germany	32,000	£21,811	62,645	£35,052
France	4,032	1,000	2,750	1,561
Italy	666	625	.....	.....
Netherlands	.....	.....	15,248	8,250
Austria	.....	.....	10,080	5,849
United States	112,795	102,550	39,984	31,880
	149,493	£125,986	130,707	£82,592

IMPORTS OF INCANDESCENT GAS-MANTLES INTO GREAT BRITAIN

Country Whence Consigned.	1920.		1921.	
	Quantity, Gross.	Value.	Quantity, Gross.	Value.
Germany	21,359	£51,710	63,756	£111,917
Netherlands	19,949	41,409	11,085	21,087
Belgium	21,663	54,225	16,301	37,182
France	1,370	3,579	330	447
Switzerland	3,962	8,672	5,619	12,959
Italy	8,769	13,817	8,175	11,625
Austria	559	1,267	2,258	2,218
United States	283	1,663	717	2,586
Other countries	445	874	113	234
Totals	78,357	£177,216	111,536	£204,832

During 1921, Great Britain exported 21,013 gross of incandescent mantles valued at £73,720, as compared with 51,737 gross, valued at £171,147, in 1920. During 1921, 8575 gross were exported to Australia, 4668 gross to India, 3146 gross to New Zealand, and 1066 gross to Argentina.

The above figures show that whereas the quantity of monazite sand imported during 1921 was about the same as in 1920 there was a large increase in the number of incandescent mantles imported. A decrease occurred in the amount of thorium nitrate imported, but it is interesting to note that 10,573 lb. of the British-made salt was exported to the United States.

Evidence, given early in 1922 before the committee appointed to hear complaints under Part 2 of the Safeguarding of Industries Act, showed that of the four factories in the United Kingdom which had previously made thorium nitrate, three were closed and one was working only half-time. Two of the works producing magnesia rings for inverted mantles were closed, and the other was producing only one-third of its normal output, while the two factories making ramie yarn were only working half-time.

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The sales in Great Britain of British-made incandescent mantles amounted, in 1921, to about 280,000 gross, as compared with about 444,000 gross sold in 1920.

WORLD'S PRODUCTION OF MONAZITE SAND
(In metric tons)

	Brazil. (a)	United States.	Travancore.	Ceylon.
1910	5,345	44.3	*Nil*	.....
1911	3,627	1.6	819	.....
1912	3,344	0.6	1,135	.....
1913	1,415	*Nil*	1,234	.....
1914	599	*Nil*	1,185	.....
1915	439	16.1	1,108	.....
1916	*Nil*	16.5	1,292	.....
1917	1,136	34.7	1,940	.....
1918	499	(b)	2,117	20
1919	146	(b)	2,057	40
1920	1,153	(b)	1,667	70
1921	.....	(b)	1,600(c)	70(c)

(a) Exports. (b) Less than three producers, no statistics published. (c) Estimated.

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NICKEL

By Thos. W. Gibson

Nickel mining has not yet recovered from the depression of the last two years or more. The mines of Sudbury, Ontario, which are the chief source of the world's supply, and the deposits of New Caledonia, have for the most part remained unworked. Early in 1921, the British America Nickel Corporation closed down mine, smelter and refinery, and was followed later by the International Nickel Co. of Canada. The Mond Nickel Co. alone has been operating, but on a reduced scale throughout the year. The cause of this stagnation is found in the accumulations of nickel, in refined metal and matte, remaining chiefly in the hands of the mining companies after the war demand died away, and awaiting the resumption of industrial activity. So long as the manufacture of steel and iron is partly suspended, so long will this condition largely obtain.

Nickel, however, has by no means gone out of use, and the statement is made by one of the leading companies that the war stocks of metallic nickel have now been mostly absorbed. There is still considerable metal locked up in matte and other intermediate products, but the companies have their mines and works well in hand and are in a position to meet the demand as it revives. The outlook is that by the end of 1922 nickel mining at Sudbury will have been resumed on a moderate scale, to be gradually increased as trade conditions improve.

The International company is taking advantage of the interregnum to dismantle its refinery at Bayonne, N. J., and to consolidate its refining facilities at its works in Port Colborne, Ont., where, it is expected, henceforward all its matte will be refined, except what is used in the manufacture of Monel metal.

Production

Canada.—At the Sudbury mines there was a total of 262,593 short tons of ore raised in 1921, more than half of which came from the mines of the Mond Nickel Co. There was 393,768 tons of ore put through the smelters, which produced 19,497 tons of matte, containing 9628 tons of nickel and 6323 tons of copper. Of the matte product, 10,466 tons was exported to the United States and Wales, to Bayonne in the former by the International company, and to Clydach in the latter by the Mond Nickel Co. The metal contents of the exported matte were nickel 4850 tons, valued at $1,939,851, and copper 3686 tons, worth $737,142, the nickel

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DISTRIBUTION OF EXPORTS OF NICKEL FROM NEW CALEDONIA, IN METRIC TONS

Year.	France.		England.		Belgium.		Germany.		United States.		Australia.		Japan.		Total.	
	Ore.	Matte.	Ore.	Matte.	Ore.	Matte.	Ore.	Matte.	Ore.	Matte.	Ore.	Matte.	Ore	Matte.	Ore.	Matte.
1914	23,380	.....	44,426	2,494	16,346	2,457	7,906	.....	.....	305	96	.....	.....	.....	92,154	5,256
1915	11,935	1,409	36,641	600	.....	.....	.....	.....	.....	3,519	.....	.....	.....	.....	48,576	5,528
1916	7,806	783	20,129	800	.....	.....	.....	.....	.....	3,352	.....	.....	2,743	.....	30,678	4,035
1917	2,880	200	15,838	1,170	.....	.....	.....	.....	25	4,949	.....	.....	3,276	.....	22,017	6,319
1918	12,259	400	.....	.....	.....	.....	.....	.....	.....	3,537	.....	.....	3,352	.....	15,611	3,937
1919	1,509	1,000	.....	52	.....	304	.....	.....	.....	2,508	.....	.....	.....	.....	1,561	3,812
1920	3,246	1,671	.....	.....	.....	343	.....	.....	.....	2,494	.....	.....	.....	.....	3,246	4,508

in the matte being computed at 20 cts. per lb., and the copper at 10 cts. per lb. The refineries in Canada, at Port Colborne and Deschenes, treated 5558 tons of matte and recovered, in addition to oxide, 2710 tons of nickel, valued at $1,821,917, and 1463 tons of copper, worth $330,084.

The Sudbury mattes contain important quantities of the platinum group of metals. The recoveries in the refineries were as follows: Platinum 268.60 troy oz., palladium 590.45 oz., also 56.05 oz. of unseparated iridium, osmium, rhodium and ruthenium. The average platinum quotation in 1921 was $75.03 per oz. These figures do not include recoveries in the United States and Great Britain from Ontario nickel-copper matte refined in these countries. For 1920, complete returns of platinum metal production are as follows: Platinum 8345 oz., palladium 10,199 oz., iridium group 512 oz. The average quotation for platinum during 1920 was $110.90 per oz. It should be borne in mind that the precious or rare metals recovered from Ontario nickel-copper mattes in any one year bear very little relation to the ore or matte treated, as residues are allowed to accumulate over a period of years.

New Caledonia.—There was little or no market for New Caledonian nickel in Europe in 1921, and most of the mines there were obliged to close down or limit their production. Société le Nickel and Société Hauts-Fourneaux de Nouméa were still operating some of their mines, and a little work was being done at the Macconnaise and Gracieuse at Dumbéa near Nouméa. The two companies named own large areas of undeveloped mining land, and also nickel smelting works. A large hydro-electric plant, with capacity of 30,000 hp., is being erected at Yate for Société le Nickel. A nickel smelting plant put up at Nouméa by a Japanese company has not yet begun operations.

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UNITED STATES IMPORTS AND EXPORTS OF NICKEL

Year.	Imports.						Exports.	
	Nickel Ore and Matte.			Nickel and Nickel Alloys. (a)		Nickel Mnfrs.	Nickel. (b)	
	Long Tons.	Nickel Content, lb.	Value.	Pounds.	Value.	Value.	Pounds.	Value.
			$		$	$		$
1906.	15,156	(c)	1,816,631	210,000	77,373	8,963	10,620,410	3,493,643
1907.	16,888	18,418,305	2,153,873	180,025	80,994	9,159	8,772,578	2,845,663
1908.	16,322	16,586,423	2,396,217	241,868	91,388	10,010	9,770,248	3,297,988
1909.	18,578	21,916,182	2,927,975	277,911	104,019	4,279	12,048,737	4,101,976
1910.	28,519	32,050,032	4,085,076	323,239	125,013	14,759	15,244,937	4,704,088
1911.	23,993	29,545,967	3,918,556	293,301	104,160	.....	25,099,586	8,283,777
1912.	33,101	42,168,769	5,638,456	223,168	103,300	17,203	25,815,016	8,515,332
1913.	37,623	47,194,101	6,427,639	336,590	133,917	37,200	29,173,088	9,686,794
1914.	29,564	35,006,770	4,956,448	109,213	45,146	13,010	27,595,152	9,455,528
1915.	45,798	56,352,582	7,615,999	32,487	13,687	6,242	26,418,550	10,038,514
1916.	59,741	72,611,492	9,889,122	29,917	7,869	25,880	33,404,011	12,952,493
1917.	61,053	75,510,793	9,612,400	15,964	4,763	45,248	21,996,412	8,940,512
1918.	59,621	73,193,205	11,517,546	10,942	3,229	115,243	17,469,500	6,927,041
1919.	23,057	29,303,228	5,780,380	7,258,070	2,553,354	90,451	3,810,656	1,697,544
1920.	32,650	41,586,108	8,463,872	6,905,968	2,193,321	200,464	1,215,232	574,845
1921.	1,507	2,042,178	432,786	2,353,941	777,531	107,155	425,851	103,372

(a) Includes metal, nickel oxide, and alloys of any kind in which nickel is the material of chief value, in ingots, bars, and sheets. (b) Comprises domestic nickel, nickel oxide, and matte. (c) Nickel content not stated.

Exports of Nickel from United States, Pounds.	1917.	1918.	1919.	1920.	1921.
To France	1,232,142	2,233,736	1,346,119	72,912	.....
To Italy	5,470,042	5,100,847	525,940	.....	.....
To Netherlands	.....	.....	57,091	.....	.....
To Russia in Europe	168,000	.....	.....	.....	.....
To United Kingdom	14,409,272	7,803,178	747,437	69,622	75
To Japan	275,018	2,063,933	582,946	352,834	103,484
To Russia in Asia	.....	.....	.....	.....	.....
To other countries	441,938	267,806	551,123	719,864	322,292
Total	21,996,412	17,469,500	3,810,656	1,215,232	425,851

CANADIAN PRODUCTION AND EXPORT

(Net Tons)

	1917.	1918.	1919.	1920	1921.
Ore mined	1,518,783	1,641,617	572,400	981,268	262,593
Ore smelted	1,453,661	1,559,892	754,567	937,874	393,768
Bessemer matte produced	78,897	87,184	42,736	57,892	19,497
Copper content of matte	21,196	23,483	12,099	15,957	6,323
Nickel content of matte	41,887	45,886	22,035	30,459	9,628
Spot value of matte	$12,004,141	.....	.....	.....	.....

	Lb., 1917.	Lb., 1918.	Lb., 1919.	Lb., 1920.	Lb., 1921.
Nickel contained in matte	82,620,400	85,767,700	30,395,400	51,701,000	19,256,900
Refined nickel	.....	1,910,800	10,621,000	8,498,300	10,632,014
Exported to Great Britain	12,400,100	13,007,600	4,617,900	13,399,900	.....
Exported to United States	70,230,300	74,613,800	34,881,500	45,451,000	.....
Exported to other countries	.....	57,100	1,517,000	1,348,400	.....
Total	82,620,400	87,678,500	41,016,400	60,199,300	29,888,914

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Of late years, little ore has been exported from New Caledonia owing to the development of local smelting plants, and the nickel is mostly now shipped in the form of matte. France takes nearly all the ore, while the matte goes chiefly to the United States. In January, 1922, however, 505 tons of matte was shipped to Antwerp and 1033 tons to Havre. In 1920, 3246 tons of ore was exported to France, also 1671 tons of matte; while to the United States, the matte shipments were 2494 tons, and to Belgium, 343 tons. The total exports thus were 3246 tons of ore and 4508 tons of matte.

Norway.—The position of the Norwegian nickel industry during 1921 was unsatisfactory. The mines were closed down early in the year, and the outlook for the industry is regarded as dubious.

Exports of nickel from Norway in 1921 amounted to 273 metric tons; in 1920 53 tons was exported.

Nickel Ore Deposits

Sudbury, Ont., Deposits.—The Sudbury deposits are of the sulphide type, consisting of pyrrhotite and chalcopyrite, the nickel-bearing mineral being pentlandite. They occur at the contact of norite and granite or greenstone. They are in the form of great lens-shaped masses, some of them containing many millions of tons; they carry on an average about 3 per cent. nickel and 1.5 per cent. copper. The Creighton mine, owned and operated by the International Nickel Co., has for a number of years been drawn upon by that company for its chief supply of ore. It is unusually rich in nickel, running up to 5 per cent. Another very large body of ore is contained in the Frood mine, owned by the same company, but the ore is more silicious and carries less nickel. The Mond company's chief deposits are Levack, Frood Extension, Garson, Worthington, also Victoria and Bruce. The Victoria, which was the company's original mine, has been worked to great depth; its ore carries unusually high proportions of the precious and rare metals. Bruce is a copper mine and carries no nickel. The British America Nickel Corporation's principal property is the Murray mine, formerly owned by the Vivians of Swansea. It contains very large bodies of ore of medium grade. This company has its smelter at Nickelton and its refinery at Deschenes, Que.

Other Canadian Deposits.—In other parts of Ontario, also in eastern Manitoba, other deposits of nickel-copper ore of the Sudbury type have been located. The Alexo mine in Dundonald township, Porcupine district, has been worked for a number of years, and has produced about 50,000 tons of good ore. It is not now in operation. At Lake Shebandowan, the International Nickel Co. did some development work in 1921

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on a deposit owned by J. G. Cross. No large bodies of ore comparable to those at Sudbury were discovered, but a number of lenses were located, the greatest width of ore being 15 ft. Other outcroppings ran from 2 to 7 ft. in width. There is a series of these lenses parallel to one another, outcroppings of which occur over the length of a mile. While the orebodies are small, they are comparatively numerous and close together, so that the aggregate tonnage might be considerable. A feature of these orebodies is their remarkable richness in places, the ore sometimes running over 10 per cent. nickel. It also carries cobalt. In one pit a mass of polydymite was found in bunches and also in vein-like stringers. The ore does not appear to carry much platinum or gold, but contains considerable silver and palladium. Arsenides are also present in small veinlets running through the ore.

H. C. Cooke of the Canadian Geological Survey examined the copper-nickel outcroppings in the Oiseau (or Bird) and Maskwa (or Bear) river areas in eastern Manitoba, during the summer of 1920. The principal ore mineral in both districts was pyrrhotite, containing more or less pentlandite and some chalcopyrite. In each district the ore minerals are concentrated within the gabbro near the original base of the sill; elsewhere in the sills only an occasional grain of sulphide or magnetite may be found here and there. The sulphides and oxides do not occur in veins, but in irregularly shaped accumulations, or segregations, within the gabbro. In places the concentration has been sufficient to form solid masses of ore minerals several feet in thickness. There is no sharp boundary between a mass of ore and the surrounding rock; the proportion of ore minerals very gradually decreases, and that of the rock mineral increases, until pure gabbro is reached. The values in the discoveries so far made are principally nickel, though copper in some amount occurs locally. Samples taken by Dr. Cooke gave by analysis 3.10 per cent. nickel and 0.07 per cent. copper. So far, prospecting has not shown whether the discoveries include any orebodies of commercial importance, and as yet the district can scarcely be pronounced a potential producer.

Union of South Africa.—In the Barberton district of South Africa exploratory work is proceeding on the property of the South Africa Nickel and Talc Mines. Two samples of ore analysed by Henry Wiggin & Co. of Birmingham show nickel plus cobalt oxides to the extent of 31.34 per cent. and 36.40 per cent. respectively, the cobalt oxide amounting in both samples to about 0.50 per cent. It was suggested that the best way to treat the ore would be to smelt it in conjunction with ores from Sudbury, which have an excess of sulphur, the addition of the South African material having the advantage of increasing the proportion of nickel in the resulting matte.

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Cuba.—The immense deposits of lateritic iron ores in Moa Bay and Mayari contain in the aggregate a very large quantity of nickel, the percentage of the metal present averaging perhaps 0.75 or 0.80 per cent. These ores are utilized in the manufacture of pig iron and steel, to which the proportion of nickel present contributes its characteristic effects. The tendency of modern practice, however, seems to be against the use of natural alloys, and to give the preference to artificial admixtures of the separate materials with the view of obtaining a more uniform product.

Recently, under the direction of C. R. Hayward of the Massachusetts Institute of Technology, elaborate and long-continued experiments were carried out in the hope of obtaining a commercial process of extracting the nickel from Cuban ores. A process was finally developed which, so far as laboratory tests and calculations are concerned, was regarded as both a technical and a commercial success. By sulphurizing and leaching the Cuban ore, about 70 per cent. of the nickel could be recovered, together with 50 per cent. of the alumina and 60 per cent. of the manganese, leaving a beneficiated iron ore, and producing gypsum and iron-oxide pigment as by-products.

Other Localities.—Nickel ores are present in many other parts of the world. Ores of the Sudbury type are found in South Africa, Germany, Norway and elsewhere. Residual deposits containing nickel and resembling those of Cuba occur in Celebes and other islands in the South Pacific Ocean, also in Madagascar, but generally considered it may be taken for granted that none of the deposits so far discovered, outside of Ontario and New Caledonia, is sufficiently rich in nickel or so conveniently situated as regards the markets as to be a serious competitor to these two countries.

Uses of Nickel

Now that the scrapping of the world's navies has cut off the market for nickel in the manufacture of armorplate for battleships, it is incumbent upon the industry to demonstrate the advantages of nickel for other uses. The principal use of nickel will probably remain as an ingredient of nickel steel, but there are many other purposes for which it is utilized, such as in electroplating, nickel-silver, cupro-nickel, as a catalyst in the hardening of oils, for cooking-utensils, anodes for storage batteries, coloring ceramic ware, etc.

Coinage.—Nickel in coinage, either as the pure metal or alloyed with copper, has been adopted in many countries. Canada, for instance, has recently issued a new 5-cent pure nickel coin, which is intermediate in size between the 10- and 25-cent silver pieces, being 0.835 in. in diameter and weighing 70 grams. About 25 tons of nickel per annum will be

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consumed for this purpose; the Mond company supplies the metal. France, however, during the war discontinued the use of pure nickel coins, owing to the fact that the cost price of the metal had run up to a point exceeding their nominal value. In 1917, and again in 1919 and 1920, new issues of coins were authorized, substituting for pure nickel an alloy of copper and nickel. These coin issues will undoubtedly not be exhausted for several years. In France, of course, nickel from New Caledonian ores was employed.

Monel Metal.—Monel metal, a now well-known product of the International Nickel Co., and containing about 67 per cent. nickel, 28 per cent. copper, and 5 per cent. of iron, manganese, silicon and carbon as impurities, is produced from nickel-copper matte without separation from each other of the nickel and copper. It is non-corrodible, very strong, tough and ductile. It can be machined, forged, soldered and welded, both electrically and by the oxy-acetylene process. It takes and retains a good nickel finish. As a resistant to acids it has great advantages, due to its non-corrodibility and strength; it is produced as rolled sheets, wire, and castings; it can be supplied as rods or ribbons and is manufactured into a variety of articles for use in power-plants, marine installations, gas and oil engines, pickling and chemical works, dye-house equipment, mining equipment, automobiles, dairy equipment, packing-houses, etc.

Malleable Nickel for Seamless Tubes, etc.—Pure malleable nickel is being made by the American Nickel Corporation at Clearfield, Pa., using Mond nickel. This material can be pierced and drawn into seamless drawn nickel tubes by the same mechanisms as are used in making seamless drawn steel tubes. The characteristic properties of nickel are claimed for the product is an eminent degree, namely, resistance to corrosion, erosion, oxidation, abrasion, and acids; it does not scale, can be welded to iron, steel, or itself, is not affected by superheated steam, or liquid air; it is very white—almost the color of silver; it can be bent double cold without fracture, can be highly polished, forged, drawn, rolled, spun, etc.

Nickel-plate.—The Steel Process Syndicate, Ltd., 61 Wind St., Swansea, Wales, is experimenting with a process for the manufacture of nickel sheets, with the object of substituting nickel for tin in the coating of tinplate. The details of the process have not yet been made public.

Research on Nickel

In common with other metals, experimentation continues to be made on nickel. Its properties, qualities, and behavior under various circumstances are being investigated by numerous research-workers.

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Madsen Process Electrolytic Nickel.—Chas. P. Madsen gives in *Chemical and Metallurgical Engineering* for May 25, 1921, an outline of his experimental work on the electrolytes, cathodes and anodes leading to the production of electrolytic nickel of greatly improved mechanical properties which possesses a higher degree of ductility than any nickel previously produced. An average analysis was Ni 99.70 per cent., Fe 0.01, Cu nil., C 0.02 per cent. It was found that the deposited metal could be heated red hot either before or after rolling without embrittling it. Wires have been drawn from a bar ⅛ in. (3 mm.) in diameter down to 0.002 in. (0.05 mm.) without annealing. This new nickel, however, develops considerable hardness and increases in tensile strength upon rolling or drawing. Tests with the Ericsson machine showed a drawing ability better than that of ordinary hard-rolled brass or copper and about equal to dead-soft copper.

Nickel and Cobalt in Cast Iron.—In *Stahl und Eisen* for Sept. 30, 1920, Prof. O. Bauer and Dr. E. Piwowarsky discussed the effect of nickel and cobalt on cast iron, based on the experiments which they had conducted. The raw material used in the test was pure Swedish charcoal pig iron containing 3.90 per cent. total carbon, 2.80 graphite, 0.048 phosphorus, 0.018 manganese, and 0.069 per cent. silicon. The nickel was used in the form of electrolytic nickel. Small melts were first of all made for obtaining the cooling curves, and it was found that the nickel easily alloyed with the pig iron at a temperature of 50° C. above the temperature of the iron. Larger melts were then made in conical graphite crucibles of 200 mm. height and 100 mm. diameter at the top. These crucibles each contained 2250 grams of pig iron, which was then melted in a Helberger furnace with a liberal addition of graphite. They were heated 100° C. above the melting point, the nickel, carefully weighed, being added in small pieces. After the mixture was thoroughly stirred with a carbon rod, the metal was poured into dry sand moulds, and gave castings 20 mm. in diameter and 650 mm. long. Four melts were made in this way, the first without any metallic addition, and the other three with various added percentages of nickel. The best results were obtained for about 1 per cent. of nickel. The increase in bending strength as compared with the original cast iron was approximately 30 per cent., the compressive strength was increased 30 per cent., and the tensile strength by only 18 per cent. On metallographic examination all melts exhibited the normal structure of a good-grade cast iron, and for the manufacture of high-quality castings for machine parts, gears, wheels, etc., the writers recommended a percentage of added nickel up to 1.20 per cent. Two test melts with added cobalt were prepared, the percentages of cobalt being 1 per cent. and 2 per cent., respectively. The results showed the effect of cobalt to be opposite

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to that of nickel; the bending strength dropped considerably and the tensile and compressive strengths exhibited a gradual increase, while the hardness increased slightly. They concluded therefore that there was no possibility of using cobalt for improving the properties of cast iron.

Nickel Brasses.—A paper by Dr. L. Guillett in *Revue de Metallurgie* for July, 1920, gives an account of his work on brasses containing nickel.

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PETROLEUM AND NATURAL GAS

By David T. Day

The curve of oil production in the United States continued upward in 1921. Not only did the total product exceed any previous record, but the increase was large; *i.e.*, from 442,929,000 bbl. in 1920 to 469,639,000 in 1921. The chief cause of the increase was the stimulus of high prices. Production necessarily lags far behind a change in price. Much time must elapse after a rise in price before the desired increase in product can materialize. Drilling is slow at best. It is especially so when the increased production must be sought chiefly in new fields. In 1921 such wildcatting developed the Eldorado field in Union County, southern Arkansas, the Haynesville and Cotton Valley pools in northern Louisiana, the Burbank pool in Oklahoma, and Mexia in Texas. In California the Huntington Beach pool was discovered and Elk Hills was developed. All these gave significant additions to the supply, but Mexia outranked the others in production and in stimulating new drilling.

Great as the production was, the consumptive demand would not have been met had not the importations from Mexico exceeded all precedent in even a greater ratio. In 1920 106,163,000 bbl. was imported from Mexico, and this rose to 125,307,000 bbl. in 1921. The effect of this upon oil prices in the United States was felt severely, but would doubtless have been even greater except for the feeling of lack of stability in Mexican oil production. Great authorities have been pronounced in the prophecy of quick exhaustion, or at least great decline, in Mexican oil due to heavy inroads of salt water.

PRODUCTION OF PETROLEUM IN THE UNITED STATES BY STATES (*a*)
(In barrels)

	1917.	1918.	1919.	1920.	1921.
Arkansas	.....	.....	.....	.....	17,071,000
California	93,877,549	97,531,997	101,183,000	103,377,000	114,709,000
Colorado	121,231	143,286	121,000	111,000	108,200
Illinois	15,776,860	13,365,974	11,960,000	10,774,000	10,044,000
Indiana	759,432	877,558	972,000	945,000	1,163,000
Kansas	36,536,125	45,451,017	33,048,000	39,005,000	36,232,000
Kentucky	3,088,160	4,367,968	9,278,000	8,738,000	8,950,000
Louisiana	11,392,201	16,042,600	17,188,000	35,714,000	26,523,000
Montana	99,399	69,323	90,000	340,000	1,435,000
New York	879,685	808,843	851,000	906,000	980,000
Ohio	7,750,540	7,285,005	7,736,000	7,400,000	7,330,000
Oklahoma	107,507,471	103,347,070	86,911,000	106,206,000	113,978,000
Pennsylvania	7,733,200	7,407,812	8,137,000	7,438,000	8,003,000
Tennessee	12,196	8,374	15,000	14,000	12,400
Texas	32,413,287	38,750,031	79,366,000	96,868,000	103,322,000
West Virginia	8,379,285	7,866,628	8,327,000	8,249,000	8,003,000
Wyoming	8,978,680	12,596,287	13,172,000	16,831,000	19,221,800
Other states(*c*)	10,300	7,943	12,000	13,000	(*b*)
	335,315,601	355,927,716	378,367,000	442,929,000	469,639,000

(*a*) U. S. Geol. Surv. (*b*) Not available. (*c*) Includes Alaska, Michigan, Missouri, etc.

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PRODUCTION OF PETROLEUM IN THE UNITED STATES, BY FIELDS (a)
(In barrels)

Field.	1920.		1921. (b)	
	Quantity.	Value.	Quantity.	Value.
Appalachian	30,630,000	$163,994,000	30,574,000	$89,500,000
Lima-Indiana	3,060,000	11,123,000	2,411,000	5,400,000
Illinois	10,774,000	39,583,000	10,935,000	23,000,000
Mid-Continent	250,111,000	840,700,000	256,085,000	408,100,000
Gulf Coast	27,682,000	75,595,000	34,160,000	39,200,000
Rocky Mountain	17,282,000	51,294,000	20,765,000	26,100,000
California	103,377,000	178,395,000	114,709,000	162,000,000
Undistributed	13,000	61,000	.....	.....
	442,929,000	$1,360,745,000	469,639,000	$753,300,000

(a) U. S. Geol. Surv. (b) Preliminary.

At the beginning of 1921 oil of Pennsylvania grade was quoted at $6.10 per bbl., and Oklahoma at $3.50. These prices gradually sank to $2.25 for Pennsylvania, and $1 for Oklahoma. By the close of the year they had risen again to $3.50 and $2.25 respectively.

Stocks increased significantly all through the year.

In the following table a summary is given of crude petroleum statistics from 1910 to 1921, showing the disposition of the domestic production and imports, and the average price per barrel of petroleum at the wells:

SUMMARY OF CRUDE PETROLEUM STATISTICS IN THE UNITED STATES (e)

Year.	Domestic Production (a).		Imports of Mineral Crude Oil. (b).		Estimated Consumption (c).		Stocks of Domestic Petroleum (d).	
	Thousands of Barrels.	Per Cent. of Yearly Increase.	Thousands of Barrels.	Per Cent. of Yearly Increase.	Thousands of Barrels.	Per Cent. of Yearly Increase.	Thousands of Barrels.	Per Cent. of Yearly Increase.
1910	209,557	14	557	696	191,483	15	131,030	+12
1911	220,449	5	1,710	207	211,150	10	137,233	+ 5
1912	222,935	1	7,383	332	240,188	14	122,870	−10
1913	248,446	11	17,809	141	261,692	9	122,803	.....
1914	265,763	7	17,247	3	261,293	.....	141,550	+15
1915	281,104	6	18,140	5	273,271	5	163,755	+16
1916	300,767	7	20,570	13	318,599	17	162,397	− 1
1917	335,316	12	30,163	47	377,736	19	146,942	−10
1918	355,928	6	37,736	25	413,078	9	121,727	−17
1919	378,367	6	52,822	40	420,462	2	129,205	+6
1920	442,929	17	106,175	101	530,532	26	133,000	+4
1921	469,639	6	125,307	18	525,407	−1	170,350	+26

(a) 1910–1918, inclusive: petroleum removed from producing properties plus oil consumed for fuel on the leases. 1919-1921: Petroleum removed from producing properties.
(b) From records of Bureau of Foreign and Domestic Commerce.
(c) Sum of domestic production and net imports plus decrease of stocks or minus increase of stocks. Stocks of Mexican petroleum held in the United States by importers amounted to 2,919,000 bbl.; Dec. 31, 1919; 7,442,000 bbl. Dec. 31, 1920; and 13,540,000 bbl. Dec. 31, 1921.
(d) Held by pipeline and other marketing companies on Dec. 31 of each year.
(e) Prepared from figures of U. S. Geol. Surv.

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AVERAGE PRICE PER BARREL AT WELLS

Grade.	1910.	1911.	1912.	1913.	1914.	1915.	1916.	1917.	1918.	1919.	1920.	1921.
Pennsylvania	$1.34	$1.30	$1.60	$2.46	$1.89	$1.56	$2.51	$3.25	$3.97	$4.13	$5.96	$3.73
Oklahoma-Kansas	0.38	0.47	0.67	0.94	0.76	0.60	1.26	1.81	2.20	2.29	3.41	$1.93

OIL WELL COMPLETIONS AND PRODUCING WELLS BY FIELDS (a)

	1919.		1920.		1921.	
	Total.	Producing Oil Wells.	Total.	Producing Oil Wells.	Total.	Producing Oil Wells.
Eastern	11,060	8,269	11,234	8,331	8,303	5,497
Mid-Continent	15,926	11,307	19,982	14,031	11,088	7,212
Gulf-Coast	1,238	649	1,760	1,034	1,076	611
Rocky Mountain	286	182	348	254	430	326
California	.....	559	.....	572	.....	704
Total, U. S	.....	20,966	.....	24,222	.....	14,350
Total east of Rockies	28,510	20,407	33,324	23,650	20,897	13,646

(a) Am. Petroleum Inst.

EXPORTS OF CRUDE OIL AND REFINED PRODUCTS FROM THE UNITED STATES IN GALLONS

Product.	1918.	1919.	1920.	1921.
Crude oil	205,829,030	248,821,453	337,886,081	372,350,885
Illuminating oil	491,109,815	9,155,147	861,891,942	748,958,821
Lubricating oil	257,317,253	4,795,166	410,874,209	289,316,620
Gasoline, naphtha	559,368,855	372,132,597	642,897,428	533,089,610
Residuum, fuel oil, etc	1,200,994,793	617,849,304	846,959,940	855,117,913
Total mineral oils	2,714,619,746	2,492,754,027	3,100,509,600	2,797,935,731

PRODUCTION BY STATES

Alabama.—Geologists of the U. S. Geological Survey, working in Coffee County, southern Alabama, have found indications of the presence of an anticline or dome which may be a favorable place for the accumulation of oil.

The strata in Coffee County, which lies in the Gulf Coastal Plain, consist of sands, clays, and marls that normally dip southward or southwestward at a rate that in few places exceeds 50 ft. to the mile. This dip is so slight that the beds appear horizontal except in unusually favorable places for observation, such as long stretches of bare ledges along streams. Departures from this normal direction and rate of dip have been noted in T. 7 N., R. 20 E., and in the western part of T. 6 N., R. 20 E., in the northwestern part of Coffee County, where the dips range from about ¾° to 2° or more toward the northwest. East of this line of flexure the beds appear so nearly horizontal that the direction of dip can not be determined with assurance by the clinometer. One southward dip of about 2° was measured in sec. 10, T. 6 N., R. 20 E.

The structure indicated by these dips is a broad, low, flat-topped or perhaps gently undulating upfold, the shape and extent of which can be determined only by careful detailed field examination.

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This upfold of the strata in Coffee County, when carefully mapped, may be found to be favorable for the accumulation of oil or gas and even preferable to the possibly similar structural features that have been reported to exist in Geneva County, which adjoins Coffee County on the south. It would not be necessary to drill so deep in Coffee County as in areas farther south.

Alaska.—The petroleum produced in Alaska in 1921, as in previous years, was derived from a single patented claim in the Katalla oil field. This property is owned by the Chilkat Oil Co., which uses its entire product in its own refinery. Except for the work done by this company, there was no drilling in the Alaska petroleum fields. The staking of Alaska oil claims began in 1920 and continued in 1921. Some claims are regions of known seepages and favorable structure and some are in wildcat territory, not uncommonly in areas where what is known of the geology is unfavorable to the occurrence of oil. Drilling in some of the Alaska oil fields will no doubt be undertaken in 1922.

In July, 1921, a petroleum seepage flowing about 2 oz. a day was found about 1 mile southwest of the town of Anchorage. This was visited by Alfred H. Brooks of the U. S. Geological Survey, who reports that it emerges from a gravel bank on top of a strata of clay. Its bed-rock source is unknown, for the region in which it occurs is largely covered by gravel, sand and clay to a depth of 200 ft. or more. Other seepages are reported near Anchorage.

An examination made under private auspices of the long-known locality of petroleum residue near Smith Bay, about 100 miles southeast of Point Barrow, is reported to have disclosed several large seepages. So far as known, these are the only new discoveries of petroleum seepages made in Alaska during 1921, though others are reported.

The U. S. Geological Survey in 1921 examined the Iniskin Bay oil region, on Cook Inlet, and a part of the Cold Bay region, on the Alaska Peninsula. The reports on this work have not yet been finished, but the general results can be announced. F. H. Moffit found that the Iniskin Bay region includes a number of long, narrow anticlines which are joined on the seaward side by a great monocline. This monoclinal structure affords a considerable drainage area and may have resulted in the accumulation of pools of oil.

S. R. Capps reports that in the Cold Bay district and probably in other parts of the Alaska Peninsula there are structural features favorable to the accumulation of oil and that these are well worth drilling. These are of such dimensions that there is a possibility of their containing large oil pools.

Arizona.—Under the terms of an agreement with a well-drilling

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company of Yuma, drilling was to begin the early part of 1922 for oil in the Mescal Gap district, 20 miles from Tombstone. Leases have been secured on 5055 acres of land.

Many geologists have examined the district, and all agree that it is favorable for oil prospecting, with indications that oil will be struck at from 2300 to 2500 ft. The company has agreed to drill to this depth, and, should indications warrant, will go further.

Arkansas.—Wildcatting was prevalent at many places in southern Arkansas, but with no significant results as to production except at Eldorado. The development of this pool began in 1920, but became very active when a large gusher was brought in quite near the town. A veritable forest of derricks went up at once, and in spite of very low prices the production justified three pipelines, which were finished during the year. The pool soon became outlined as an oval nearly north and south. During the year it was extended several miles to the south, with some improvement in quality. Salt water was found so close under the oil as to require great care in bringing in the wells. Late in the year several gas wells, and afterwards oil wells, extended the field to the east, and no limitation has been reached in that direction. As soon as the eastern limit is defined wildcatting will doubtless turn to

TOTAL PRODUCTION OF

Year.	Kern River.	McKittrick.	Midway.	Sunset.	Coalinga.	Santa Maria-Lompoc.
Prior	.....	.....	.....	.....	.....	.....
1890	.....	.....	.....	.....	•	.....
91	.....	.....	.....	•	.....	.....
92	.....	•	.....	.....	.....	.....
93	.....	.....	.....	.....	.....	.....
94	.....	.....	.....	.....	.....	.....
95	.....	.....	.....	.....	.....	.....
96	.....	.....	.....	.....	14,119	.....
97	.....	.....	.....	.....	70,140	.....
98	.....	10,000	.....	.....	154,000	.....
99	•	15,000	.....	.....	439,372	.....
1900	826,775	80,000	•	12,500	547,960	.....
01	3,278,840	430,450	4,235	188,600	525,433	•
02	8,988,046	619,296	3,048	167,558	571,233	86,888
03	16,342,099	1,353,206	27,305	352,565	2,138,058	204,890
04	17,226,240	1,856,225	910	390,425	5,097,853	700,450
05	15,253,845	1,373,030	18,530	419,212	8,882,125	3,402,800
06	12,825,166	680,756	11,800	307,550	8,401,105	4,799,411
07	12,346,014	2,415,840	149,944	704,805	8,996,268	8,249,236
08	13,803,579	3,076,300	434,578	1,463,520	10,725,795	8,699,350
09	14,508,242	5,807,360	2,234,455	1,999,701	15,406,619	8,017,455
1910	14,776,345	5,471,613	11,174,207	9,218,904	18,646,570	7,607,830
11	14,078,890	5,477,532	21,584,602	5,559,069	18,311,251	7,465,074
12	12,446,445	5,094,465	25,948,980	5,590,824	19,546,122	6,801,966
13	9,980,940	4,496,842	33,040,129	5,984,651	18,604,626	5,817,711
14	7,930,545	3,820,857	37,479,228	12,546,615	15,925,887	4,303,080
15	8,034,974	3,552,801	33,311,486	6,006,607	13,548,159	4,536,840
16	8,402,525	3,230,644	32,156,818	6,768,658	14,381,493	4,422,410
17	8,495,610	3,252,544	29,487,812	7,072,333	15,938,543	5,789,070
18	7,921,515	3,050,627	27,439,993	6,608,940	16,283,066	7,143,750
19	7,563,025	2,810,848	26,414,067	5,589,885	16,385,610	6,030,910
1920	7,456,515	2,607,240	32,493,229	5,423,781	15,464,198	5,928,060
1921	6,715,680	2,056,101	(a)46,871,740	(b)	12,340,637	5,563,324
Total	228,301,945	62,639,577	360,287,096	82,376,693	257,346,242	105,586,805

• Indicates first well. (a) Includes Sunset. (b) Included in Midway. (c) Includes Huntington

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several good structures which have been noted on the western edge of Union County.

The Eldorado field draws its supply from the Nachitoch sand at about 2100 ft. Deeper sands are probable.

California.—According to the score of Dr. Geo. B. Richardson, the Geological Survey's petroleum expert, California came out first among the states in 1921 by a very close margin, *viz.*, California 114,709,000 bbl., Oklahoma 113,978,000 bbl. Both States were equally close in 1920, when Oklahoma led. California increased 9,000,000 bbl. over 1920. This was not expected, as no great pools were discovered. The increase came from pools opened in 1920, but which only reached adequate development in 1921. Stocks increased by 12,781,641 bbl. during the year. Prices were not greatly affected, as it is not easy to forecast continued production up to the present rate.

The Midway-Sunset, including Elk Hills and the Whittier-Fullerton fields, gave the remarkable increase. Most of the other districts showed a slight decline. The Huntington Beach field, which was opened in 1920, became a decided feature in 1921 and its production is now given as a new district. It produced over 2,500,000 bbl. in 1921. The total production for all years for all districts in California is given below:

CRUDE OIL IN CALIFORNIA (*d*)

Summerland.	Newhall and Ventura Co.	Los Angeles and Salt Lake.	Whittier-Fullerton.	Lost Hills-Belridge.	Miscellaneous.	Total.
.....	3,283,262	.....	.....	.....	.....	3,283,262
.....	307,360	.....	.....	.....	.....	307,360
.....	323,600	.....	.....	.....	.....	323,600
.....	385,049	.....	.....	.....	.....	385,049
.....	470,179	.....	.....	.....	.....	470,179
1,500	524,469	257,109	.....	.....	.....	783,078
16,904	476,490	751,945	.....	.....	.....	1,245,339
39,792	298,866	905,003	.....	.....	.....	1,257,780
130,136	368,282	1,327,011	12,000	.....	4,000	1,911,569
132,217	427,000	1,462,871	60,000	.....	3,000	2,249,088
208,370	496,200	1,409,356	108,077	.....	1,500	2,677,875
183,486	443,000	1,722,887	254,397	.....	248,945	4,319,950
203,616	472,057	2,304,432	302,652	.....	.....	7,710,315
143,552	475,000	2,198,496	1,103,793	.....	.....	14,356,910
131,125	682,185	793,765	2,305,613	.....	3,670	24,334,481
120,506	650,779	1,241,304	2,224,550	.....	39,392	29,548,634
96,871	476,898	2,226,768	2,118,312	.....	29,650	34,298,041
72,810	404,379	2,675,650	2,434,512	.....	10,090	32,623,229
69,060	435,584	3,372,465	3,294,206	.....	69,090	40,102,512
67,862	498,015	5,138,959	4,273,314	.....	125,475	48,306,737
66,338	516,628	4,350,898	5,157,252	.....	126,775	58,191,723
74,725	652,575	3,729,618	6,281,221	4,900	58,970	77,697,568
71,255	661,785	3,223,661	7,081,165	168,410	61,350	83,744,044
65,715	859,885	3,073,427	7,919,779	2,680,961	45,870	90,074,439
62,406	1,022,052	2,898,846	10,657,053	5,274,553	27,375	97,867,184
55,743	968,421	2,504,475	14,130,548	4,830,921	27,375	103,623,695
53,000	1,036,305	2,110,133	13,030,549	4,318,550	27,375	89,566,779
56,775	1,122,033	1,721,453	14,679,672	4,852,431	27,450	91,822,362
56,570	1,186,407	1,501,799	18,155,440	6,295,329	27,375	97,267,832
54,613	1,386,518	1,397,781	24,903,613	5,420,079	27,375	101,637,870
53,680	1,792,465	1,341,415	28,657,683	4,554,821	27,375	101,221,784
54,910	2,122,449	1,311,264	28,694,163	4,139,767	25,610	105,721,186
54,155	2,375,479	1,344,926	31,681,417	3,261,281	(c)2,585,184	114,849,924
2,390,692	28,874,428	56,186,458	230,338,202	45,802,003	3,591,237	1,381,344,589

Beach (2,561,149 bbl.), Watsonville, etc. (*d*) *Stand. Oil Bull.*

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Illinois.—Production was practically steady at 10,000,000 bbl., the decline being checked largely by increased drilling in the southwestern part of the State, where Dr. H. Foster Bain, then State Geologist, worked out the Centralia anticline 18 years ago, which yielded the Wamac pool in 1921. This is well described by H. A. Wheeler in the *Engineering and Mining Journal* of Feb. 4, 1922. There are five producing sands, beginning with the "Dykstra" sand at 600 ft. and continuing to the Trenton limestone, which should be found at about 2500 ft.

A map of the oil and gas pools of Illinois similar to that for Kansas, described in detail in the 1920 MINERAL INDUSTRY report, was published during the year by the U. S. Geological Survey.

Indiana.—There was little incentive to drilling outside of productive areas. The total wells completed declined from 468 in 1920 to 315 in 1921. The product increased, however, from 945,000 to 1,163,000 bbl. in 1921, on account of better producers obtained in the Princeton field and elsewhere in the southwestern part of the State.

Kansas.—Production declined from 39,000,000 bbl. in 1920 to 36,232,000 in 1921, and it will require the development of some new pools which cannot be foreseen to prevent a considerably greater decline in 1922. Drilling was most active in Butler and Marion counties. Butler led in number of wells completed and Marion in the amount of oil per well. The Peabody, Ebling and especially the Florence-Wischel pools, which constitute the northern part of the deep sand development, showed a total greater than for the previous year. The Eldorado district declined, and the Augusta district held its own.

Kentucky.—Kentucky slightly exceeds West Virginia in oil importance. In 1920 Kentucky produced 8,738,000 bbl., and in 1921 held its own at 8,950,000 bbl. against the low prices. Wells were drilled in 54 counties of the State; 2476 were put down—a decline from 2875 in 1920. Most of the activity was in the shallow district in Warren, Allen, Simpson, Barren, Lee, etc., in western Kentucky, but there was great activity also in Lawrence, Wolf, Wayne, Johnson, and McGoffin counties in the eastern district.

Louisiana.—Production remained almost stationary in coastal Louisiana. The northern district showed a decline in spite of the excitement due to a 1500-bbl. well in Bossier Parish, and the development of the Haynesville pool near the Arkansas line. This pool was opened in March and quickly rose to 48,000 bbl. a day, exceeding the output of the Eldorado pool in Arkansas. Extensions are being made to the pool. An important find of natural gas was developed at Cotton Valley.

An oil and gas pool map of Louisiana may be obtained from the U. S. Geological Survey.

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Michigan.—Five wells were drilled during the year, with a total of only 3 bbl. a day.

Mississippi.—Observations made by the U. S. Geological Survey and the Mississippi State Geological Survey in the vicinity of Yazoo City, Miss., have thrown new light on the question of the possible presence of oil in Mississippi and on the location of points that may be favorable for test drilling. No anticline or dome was mapped, and it is uncertain whether the facts noted afford adequate ground for the location of the axis or highest point of a fold in the strata, for the region is thickly covered with loess, bedrock is exposed at only a few localities, and the identity of the beds seen from place to place is uncertain. Nevertheless the Survey geologist, L. W. Stephenson, and the State Geologist, E. N. Lowe, say that folding appears to be indicated by the reversal of dips of Eocene beds in the basin of Tesheva Creek near Free Run, an abandoned post office about 10 miles in an air-line northeast of Yazoo City. The reverse dips, which appear to amount to 40 or 50 ft. to the mile, are shown by lignite seams belonging to the Yegua formation, the uppermost formation of the Claiborne group, and by associated irregularly bedded, poorly exposed sands and clays, along several small tributaries of Tesheva Creek east and northeast of Free Run.

Owing to the thick covering of loess in the vicinity of Free Run the geologic structure can not be mapped from surface observations, but the apparent dip of the strata indicates that the crest of the fold lies probably within a mile or two southwest or south of the ravines in which the lignite seams were noted. The succession of beds to be drilled through would probably be similar to that penetrated at Jackson, Miss., where two test wells, respectively 3043 and 3079 ft. deep, were drilled. These wells penetrated a succession of clays and sands and toward the bottom several hundred feet of chalk. According to the interpretations placed upon their logs, they are supposed to have penetrated all the Tertiary formations below the Jackson formation and part of the underlying upper Cretaceous beds and were abandoned before they passed through the Selma chalk. They failed, therefore, to test the sands of the Eutaw and Tuscaloosa formations, which underlie the Selma chalk. Although neither the thickness nor the character of the deeply buried Tertiary and Cretaceous strata in the vicinity of Free Run are known, the section there doubtless does not differ greatly from that at Jackson, and if this assumption is true a 4000-ft. well would probably be deep enough to test all of the Eocene section and most of the Upper Cretaceous section, including the sands of the Eutaw and Tuscaloosa formations.

Oil has not yet been found in commercial quantities in the Coastal Plain of either Mississippi or Alabama, although a number of wells have

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been drilled there on pronounced anticlines; and their failure to obtain oil prohibits any great optimism concerning the presence of oil in the Coastal Plain of Mississippi. Showings of both oil and gas, however, have been reported in this region, and it is by no means certain that even the folds which have been drilled are in fact adequately tested. It may therefore be justifiable to prospect at places in Mississippi where good anticlinal structure occurs, although the risk of failure is admittedly very high.

Montana.—Montana entered into the column of oil-producing states with a product of 340,000 bbl. in 1920, and easily increased that to 1,435,000 in 1921. The only considerable production came from the Cat Creek field, which was provided with a pipeline. The Devil's Basin field sold 1138 bbl., and much more could have been supplied from other enterprises had there been demand for this grade of black oil. In 1921 74 oil wells were completed in the Cat Creek field and 20 elsewhere in the State. The Soap Creek pool, 20 miles south of Hardin, in Big Horn County, near the Wyoming line, has five producers of black oil, and the elaborate report of W. T. Thom, Jr., and Gail F. Moulton, of the U. S. Geological Survey, will greatly aid in the development of the region. The Survey also published information on the oil and gas probabilities in the Lake Basin region, and in northeastern Montana. A similar report covers the Cedar Creek anticline and vicinity, in Montana, North Dakota and South Dakota. Another report deals with the oil fields of central Montana, the Alice Dome, a promising anticlinal structure, while another considers the geology of northern Fergus County. The Ohio Oil Co. is to build a pipeline from Elk Basin, Wyo., 72 miles to Billings, Mont.

Ohio.—Central and eastern Ohio remained stationary as to production. It is only the deep wells with their usually steady production which prevented a decline, for no new pools were developed.

The North Lima field in northwestern Ohio was extended by drilling in McDonald township in Hardin County. Paulding and Darke counties were also interesting, and the most active drilling took place in a new "McComb" field in Pleasants township, Hancock County. These will affect the production of 1922.

Oklahoma.—Rather unexpectedly Oklahoma made an increase from 103,377,000 bbl. in 1920 to 114,709,000 in 1921. This was even a greater increase than for the previous year, and in the face of a market which declined from $3.50 per bbl. down to $1.00. New pools which were opened in 1920 accounted for the increase. Chief of these developments was the Burbank pool, in the western part of Osage County. No failures were found anywhere inside the pool, which is about 4 miles long and varies from 1 to 2½ miles wide, running northwest and southeast. The extent of the pool was not defined during the year. East of the pool a few

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new wells have been drilled. The Hewitt pool, in Carter County, was also important, due to its developing a number of deep sands. The pool was also extended to the southeast. In Okfuskee County a great pool, called the Lyons, was developed in Section 25, T. 11, R. 11, which is the same range and township which produced the Deaner pool last year. The big pay came below 2500 ft. The Bristow pool, discovered in Creek County in 1920, added another, the Continental pool, in 1921, with very prolific wells. It is not yet defined. Many other smaller developments helped to make up for the decline in older districts, and give promise of further development in 1922.

In all 3364 fewer wells were completed in Oklahoma than in 1920, but the average initial production was greater by half. This can undoubtedly be attributed to some extent to more careful drilling.

A map of the oil and gas pools of Oklahoma has recently been published by the U. S. Geological Survey.

Pennsylvania.—At the beginning of 1921 the price of Pennsylvania-grade oil had reached the high mark of $6.10 per bbl. and on every hand activity was evident for drilling for slight producers wherever previous experience had made this promising. Even wildcatting for new pools was under consideration. Then came the quick drop in crude to $2.00 a bbl. Such a price prohibits drilling, and even operating old, small pumpers is frequently a losing proposition. Hence Pennsylvania failed to register a favorable response to the high price with which the year began, but the stimulus did prevent a loss. The product remained about 8,000,000 bbl. One lone gusher was obtained, in Greene County. It started at 1600 bbl. and still yields 50 bbl. Several fine gas wells were obtained in Clarion County. The price of natural gas increases steadily.

The U. S. Geological Survey published during the year a detailed map of the oil and gas pools of the State of Pennsylvania.

Tennessee.—Drilling was carried on in 12 counties in Tennessee during 1921, with a total of 31 wells drilled. These were chiefly in Sumner and Pickett counties, though more attention will probably be directed to the western Highland rim in the near future. The outlook is as good there as in western Kentucky, if not better.

Texas.—The increase in production in northern-central and eastern-central Texas brought the total product for the State from 96,868,000 bbl. in 1920 to the unprecedented total of 103,322,000 in 1921.

The outstanding element of the monster total in Texas was the development of the Mexia pool in Limestone County—the largest field for its acreage in the United States. It is a small narrow pool and its great product came from only 62 wells drilled by the end of 1921. Since the

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end of the year drilling has been most active and already the peak of production has been passed. The other pools of northern-central Texas showed the effect of lower prices by fewer new wells completed, and this decline was partly due also to a great drought in the last half of the year. The Burkburnett pool showed a great decline in drilling activity, but the wells showed wonderful staying qualities, so that the decline was unexpectedly slight. The Panhandle region was the chief center of speculative interest.

Early in 1921 the Gulf Production Co. completed an oil well known as the No. 2. Burnett, located 18 miles northwest of Panhandle, in Carson County. It is 3027 ft. deep and flowed about 500 bbl. a day. It was shut in promptly and the oil has not been utilized. This well followed the discovery of several gas wells producing as much as 100,000,000 cu. ft. per day. Many wells are being drilled as near as possible to this well, and beyond doubt the possibilities of the Panhandle section will be well tested in 1922. Young County produced the Bunger pool, which has several prolific sands between the depths of 1800 and 3500 ft. Archer County has become a producer, near Archer City. Stephens County showed a marked decline in the latter half of 1921, but is still a most important district. The Carry pool, near Breckenridge, the Hart pool, in the eastern part of the county, and the Ivan and Eliasville pools, to the north, were the most interesting features of Stephens County. There were no interesting discoveries in Eastland County. The Hogtown-Desdemona pool, in Comanche County, caused a flurry during the year to the extent of 20,000 bbl. a day, which has settled to 5000. Wichita County contains such settled regions as Electra, Burkburnett, etc. They showed comparatively small declines during the year.

The Gulf Coast region produced two interesting pools, Pierce Junction and Orange, and their added production was the chief cause of a total increase of 7,500,000 bbl. over 1920; yet fewer wells were drilled. Deeper drilling of many old wells also helped the increase, especially at West Columbia, Goose Creek and Hull. The new Pierce Junction pool is 8 miles south of Houston. The first well was brought in there in July, by McSweeney & Snowden, whose well gave an initial flow of 2500 bbl. from a depth of 3860 ft. A 6000-bbl. well came in in August. The subsequent drilling was very irregular in its results, giving many salt-water wells. The Orange pool is near the Louisiana line. The Rio Bravo Co., a subsidiary of the Southern Pacific Co., obtained a small well there in 1913 which is still yielding 15 bbl. a day. Several other attempts were made to develop a field, but were unsuccessful until April, 1921, when local capital got two fair wells. This led the large operators to take the pool seriously and the Oil and Refining Co. got a well at 50,000 bbl. initial

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production. Oil was obtained at several horizons, but the best production came from 3950 ft. The production has proved sufficient to necessitate two new pipelines.

Interest has been aroused again in west Texas, in the trans-Pecos region. An unusually severe hurricane in June did at least $1,000,000 damage to derricks and tanks.

Utah.—The following discussion of possible oil in southern Utah was published as a press notice by the U. S. Geological Survey under date of Apr. 17, 1922:

The discovery of light oil of good grade in southern Utah and the knowledge that there are some large anticlines in that region has attracted oil operators to that part of the State. Oil has been obtained from wells in two districts in the State, one on San Juan River, some miles west of the town of Bluff, in San Juan County, the other near Virgin City, in Washington County. Little oil has been produced commercially in either of these districts, however, partly because of the great difficulties of transportation, but mainly because of rather unfavorable geologic conditions.

The possibility of obtaining oil in southern Utah in the region between and somewhat north of the two small oil fields just mentioned was investigated during the summer of 1921. A party under the direction of R. C. Moore made a reconnaissance examination of much of Kane and Garfield counties and completed a detailed survey of the large structural dome in eastern Garfield County known as Circle Cliffs. The essential objects of the survey were to locate structural features that indicate favorable places for prospecting for oil, to trace accurately the geologic formations that are exposed in the region, to examine the rocks for indications of oil, and to make a special study of the structure of the Circle Cliffs.

Rocks saturated with oil or containing noticeable indications of it were found in parts of the Moenkopi formation (Triassic) in the Circle Cliffs, and showings and seepages of oil were found in the overlying Shinarump conglomerate, also Triassic, in the Circle Cliffs and along Colorado River above the mouth of the Escalante. Oil-saturated Moenkopi beds have also been found in the San Rafael Swell. The oil-bearing formation of the San Juan field is older than any rocks that appear at the surface in Kane and Garfield counties and is therefore not exposed here, but it should lie within drilling depth beneath Circle Cliffs.

The Circle Cliffs form one of the largest and best-defined anticlines in southern Utah. The cliffs, which are composed of Jurassic sandstone (the Wingate formation of Gregory) form an almost impassable wall that surrounds a lower elliptical area about 10 or 12 miles wide and 30 miles long. The longer axis of this cliff-walled inclosure trends north-northwest. The rocks in the cliffs belong to the Triassic and Permian systems, and the lowest formations (Kaibab limestone and Coconino sandstone) are found in canyons in the central part of the area. The Circle Cliffs consists of an asymmetrical anticline, whose crest, except at its north end, marks the main divide between the streams that flow southwestward into Escalante River and those that flow eastward into Hall's Creek. The anticline is really an especially high part of the great Water Pocket fold, which can be traced from a point beyond Colorado River on the south to Thousand Lake Mountain on the north, a distance of about 80 miles. The beds on the southwest side of the Circle Cliffs anticline have a rather uniform dip, which for many miles amounts to about 250 ft. to the mile. In the Kaiparowits

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Plateau, 25 miles distant, the beds are still inclined to the southwest, and the Kaibab limestone is there probably not less than 5500 ft. lower than in the central part of the Circle Cliffs. The beds on the east side of the anticline have a very steep dip, which averages about 30°, but which is in places as much as 60°. By this down-warp the Kaibab limestone, which has an elevation of 6500 ft. in the highest part of the fold, is carried to a depth of 2000 ft. below sea-level in a distance of 5 miles. The dip of the beds along the axis to the northwest and southeast is only about 70 ft. to the mile, being thus much more gentle than the dip on either of the flanks. The closure in this anticline is at least 1000 ft. At its south end the crest of the fold is rather sharp and narrow, but toward the north it becomes broader and less sharply defined. The detailed survey shows no minor domes or large terraces on the flanks of the main dome.

Near the town of Escalante there is a much smaller anticline with a steeply dipping west limb and a gently dipping east limb. The sandstone that has been called Navajo by Gregory is the surface formation over the central part of this anticline. There are also in the region other minor structural features that have not yet been examined in detail. A test well started by the Ohio Oil Co. near the crest of the Circle Cliffs anticline in January, 1921, reached a depth of 3212 ft. in November, 1921, when it was abandoned. The drill penetrated about 1660 ft. of Coconino and Supai strata (Permian and Pennsylvanian?) and in the lower part of the well encountered thick limestone and sandstone that are probably equivalent to the Goodridge formation (Pennsylvanian), which contains the oil in the San Juan oil field. The failure to discover commercial accumulations of oil in these beds in this large anticline was a severe disappointment. Other test wells in the Circle Cliffs, even if drilled deeper, would probably not show different results, but this well by no means condemns other anticlines in this region, such as the geologically similar San Rafael Swell, farther north. The record of the Circle Cliffs well is of high geologic value as an aid to the study of the Carboniferous strata in other parts of the Southwest.

As the Circle Cliffs well was started at a horizon below the oil-bearing sands in the Moenkopi and Shinarump formations, the lower parts of which crop out at the surface in Circle Cliffs, wells drilled to test the possibility of obtaining oil in commercial quantity from these sands must be located on favorable anticlines where the Moenkopi and Shinarump formations are not exposed at the surface and are within practicable drilling depth. In the anticline just east of the town of Escalante these sands lie about 1700 to 2000 ft. below the surface.

Oil-bearing rocks occur in southern Utah, and prospecting in areas where the structure is favorable will be continued.

West Virginia.—Many localities are available where light producers of oil can be had for the drilling with quite certain results, but this did not prove tempting in view of the collapse of prices. Only the De Kalb district, in Gilmer County, was very active and the limits to the field were defined. Drilling went on in Wyoming, Mason, Logan and Micholas counties. The total product declined from 8,249,000 bbl. in 1920 to 8,003,000 in 1921.

Wyoming.—The Salt Creek field, the oldest and most important field of Wyoming and indeed the most important between the Mid-Continent field and the Pacific Coast, registered a great increase in 1921 in spite of

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very low prices. The field produced 10,051,000 bbl. in 1920, and increased this to 12,133,000 in 1921. The Lance Creek pool continued to decline very rapidly, and Big Muddy showed that it has passed its peak. Some other pools showed increases, so that apart from the Salt Creek field the State neither gained nor lost. It has become evident that the Rock River pool is a large asset to the State. A new pool of heavy black oil was opened about 18 miles southeast of Lander, known as the Derby dome. It was developed by the Anglo United Oil Fields Co. The wells have averaged 80 bbl. a day. Many interesting wildcat wells were drilled in well-scattered areas over the State, but without significant result except to negative expectations on what were considered excellent structures. In all 323 productive wells and 55 dry holes represent the drilling activity of the year, an improvement over 1920.

An oil-field map of Wyoming was issued in the series of maps showing the oil fields in certain States that is being prepared by the Geological Survey. Besides showing by colors the locations of the oil and gas pools, including every district that has yielded either oil or gas in commercial quantity, it indicates by appropriate colors and symbols the locations of pipelines and refineries and the positions and names of 192 anticlines. These anticlines include all that have been mapped by the geologists of the Survey and a large proportion of those that have been discovered through the activities of the principal oil companies operating in Wyoming. In spite of the large number of anticlines shown they do not include all that exist in the State. The spacing and trend of the folds as they appear on the map show that there must be many not yet discovered. For example, the long stretch along the east front of the Laramie Mountains, between the anticlines near Douglas on the north and those near Cheyenne and Laramie on the south, must contain a number of anticlinal folds, and if oil is discovered in quantity in either of the groups of anticlines mentioned intensive prospecting will doubtless discover many more in the intervening region. Similarly, so far as the map shows, the east front of the Big Horn Mountains is strikingly free from anticlinal folds, but this absence of folds must be more apparent than real. The geological conditions in this area are such that it is not only difficult to determine the position and extent of anticlines, but also to learn the depth to which drilling would have to be carried on them in order to reach the oil-bearing formations. Many believe that this depth is so great as to render the chances of success very doubtful, and therefore there is but slight incentive for undertaking the expensive work needed to discover and map these folds.

Southern Sweetwater County is another area where anticlines not shown on the map must exist. This is sufficiently indicated by the extent

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WORLD'S MARKETED PRODUCTION OF CRUDE PETROLEUM, 1857-

Year.	Roumania.	U. S. A.	Italy.	Canada.	Russia.	Galicia.	Japan.[1]	Germany.
1857	1,977	.....	.....	.....	.....	.....	.....	.....
1858	3,500	.....	.....	.....	.....	.....	.....	.....
1859	4,349	2,000	.....	.....	.....	.....	.....	.....
1860	8,542	500,000	36	.....	.....	.....	.....	.....
1861	17,279	2,113,009	29	.....	.....	.....	.....	.....
1862	23,198	3,056,690	29	11,755	.....	.....	.....	.....
1863	27,943	2,611,309	58	82,814	40,816	.....	.....	.....
1864	33,013	2,116,109	72	90,000	64,586	.....	.....	.....
1865	39,017	2,497,700	2,265	110,000	66,542	.....	.....	.....
1866	42,534	3,597,700	992	175,000	83,052	.....	.....	.....
1867	50,838	3,347,300	791	190,000	119,917	.....	.....	.....
1868	55,369	3,646,117	367	200,000	88,327	.....	.....	.....
1869	58,533	4,215,000	144	220,000	202,308	.....	.....	.....
1870	83,765	5,260,745	86	250,000	204,618	.....	.....	.....
1871	90,030	5,205,234	273	269,397	165,129	.....	.....	.....
1872	91,251	6,293,194	331	308,100	184,391	.....	.....	.....
1873	104,036	9,893,786	467	365,052	474,379	.....	.....	.....
1874	103,177	10,926,945	604	168,807	583,751	149,837	.....	.....
1875	108,569	8,787,514	813	220,000	697,364	158,522	4,566	.....
1876	111,314	9,132,669	2,891	312,000	1,302,528	164,157	7,708	.....
1877	108,569	13,350,363	2,934	312,000	1,800,720	169,792	9,560	.....
1878	109,300	15,396,868	4,329	312,000	2,400,960	175,420	17,884	.....
1879	110,007	19,914,146	2,891	575,000	2,761,104	214,800	23,457	.....
1880	114,321	26,286,123	2,035	350,000	3,001,200	229,120	25,497	9,310
1881	121,511	27,661,238	1,237	275,000	3,601,441	286,400	16,751	29,219
1882	136,610	30,349,897	1,316	275,000	4,537,815	330,076	15,549	58,025
1883	139,486	23,449,633	1,618	250,000	6,002,401	365,160	20,473	26,708
1884	210,667	24,218,438	2,855	250,000	10,804,577	408,120	27,923	46,161
1885	193,411	21,858,785	1,941	250,000	13,924,596	465,400	29,237	41,360
1886	168,606	28,064,841	1,575	584,061	18,006,407	305,884	37,916	73,864
1887	181,907	28,283,483	1,496	525,655	18,367,781	343,832	28,645	74,284
1888	218,576	27,612,025	1,251	695,203	23,048,787	466,537	37,436	84,782
1889	297,666	35,163,513	1,273	704,690	24,609,407	515,268	52,811	68,217
1890	383,227	45,823,572	2,998	795,030	28,691,218	659,012	51,420	108,296
1891	488,201	54,292,655	8,305	755,298	34,573,181	630,730	52,917	108,929
1892	593,175	50,514,657	18,321	779,753	35,774,504	646,220	68,901	101,404
1893	535,655	48,431,066	19,069	798,406	40,456,519	692,669	106,384	99,390
1894	507,255	49,344,516	20,552	829,104	36,375,428	940,146	171,744	122,564
1895	575,200	52,892,276	25,843	726,138	46,140,174	1,452,999	141,310	121,277
1896	543,348	60,960,361	18,149	726,822	47,220,633	2,443,080	197,082	145,061
1897	570,886	60,475,516	13,892	709,857	54,399,568	2,226,368	218,559	165,745
1898	776,238	55,364,233	14,489	758,391	61,609,357	2,376,108	265,389	183,427
1899	1,425,777	57,070,850	16,121	808,570	65,954,968	2,313,047	536,079	192,232
1900	1,628,535	63,620,529	12,102	913,498	75,779,417	2,346,505	866,814	358,297
1901	1,678,320	69,389,194	16,150	756,679	85,168,556	3,251,544	1,110,790	313,630
1902	2,059,935	88,766,916	18,933	530,624	80,540,044	4,142,159	1,193,038	353,674
1903	2,763,117	100,461,337	17,876	486,637	75,591,256	5,234,475	1,209,371	445,818
1904	3,599,026	117,080,960	25,476	552,575	78,536,655	5,947,383	1,419,473	637,431
1905	4,420,987	134,717,580	44,027	634,095	54,960,270	5,765,317	1,472,804	560,963
1906	6,378,184	126,493,936	53,577	569,753	58,897,311	5,467,967	1,710,768	578,610
1907	8,118,207	166,095,335	59,875	788,872	61,850,734	8,455,841	2,001,838	756,631
1908	8,252,157	178,527,355	50,966	527,987	62,186,447	12,612,295	2,070,145	1,009,278
1909	9,327,278	183,170,874	42,388	420,755	65,970,350	14,932,799	1,889,563	1,018,837
1910	9,723,806	209,557,248	50,830	315,895	70,336,574	12,673,688	1,930,661	1,032,522
1911	11,107,450	220,449,391	74,709	291,096	66,183,691	10,519,270	1,658,903	1,017,045
1912	12,976,232	222,935,044	53,778	243,336	68,019,208	8,535,174	1,671,405	1,031,050
1913	13,554,768	248,446,230	47,256	228,080	62,834,356	7,818,130	1,942,009	(a)995,764
1914	12,826,579	265,762,535	39,849	214,805	67,020,522	(a)5,033,350	2,738,378	(a)995,764
1915	12,029,913	281,104,104	43,898	215,462	68,548,062	4,158,899	3,118,564	(a)995,764
1916	10,298,208	300,767,158	50,652	198,123	72,801,110	6,461,706	2,997,178	(a)995,764
1917	(a)3,681,870	335,315,601	50,334	205,332	(a)69,000,000	5,965,447	2,898,654	1,000,000
1918	8,730,235	355,927,716	35,953	304,741	40,456,182	5,591,620	2,449,069	711,260
1919	6,517,748	378,367,000	38,254	220,100	34,284,000	6,255,300	2,120,500	(e)925,420
1920	7,435,344	442,929,000	34,180	196,937	25,429,600	5,606,116	2,139,177	212,046
1921	8,347,000	469,639,000	35,000	190,000	28,500,000	3,665,000	2,600,000	200,000

[1] And Formosa. (a) Estimated. (b) Includes British Borneo.

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1921 BY YEARS AND BY COUNTRIES, IN BARRELS OF 42 GAL.

India.	Dutch E. Ind.	Peru.	Mexico.	Trinidad.	Egypt.	All Other. (c)	Total.	Year.
.....	.....	.....	.....	.....	.....	.....	.....	1857
.....	.....	.....	.....	.....	.....	.....	.....	1858
.....	.....	.....	.....	.....	.....	.....	6,349	1859
.....	.....	.....	.....	.....	.....	.....	508,578	1860
.....	.....	.....	.....	.....	.....	.....	2,130,917	1861
.....	.....	.....	.....	.....	.....	.....	3,091,692	1862
.....	.....	.....	.....	.....	.....	.....	2,762,940	1863
.....	.....	.....	.....	.....	.....	.....	2,303,780	1864
.....	.....	.....	.....	.....	.....	.....	3,715,524	1865
.....	.....	.....	.....	.....	.....	.....	3,899,278	1866
.....	.....	.....	.....	.....	.....	.....	3,708,846	1867
.....	.....	.....	.....	.....	.....	.....	3,990,180	1868
.....	.....	.....	.....	.....	.....	.....	4,695,985	1869
.....	.....	.....	.....	.....	.....	.....	5,799,214	1870
.....	.....	.....	.....	.....	.....	.....	5,730,063	1871
.....	.....	.....	.....	.....	.....	.....	6,877,267	1872
.....	.....	.....	.....	.....	.....	.....	10,837,720	1873
.....	.....	.....	.....	.....	.....	.....	11,933,121	1874
.....	.....	.....	.....	.....	.....	.....	9,977,348	1875
.....	.....	.....	.....	.....	.....	.....	11,051,267	1876
.....	.....	.....	.....	.....	.....	.....	15,753,938	1877
.....	.....	.....	.....	.....	.....	.....	18,416,761	1878
.....	.....	.....	.....	.....	.....	.....	23,601,405	1879
.....	.....	.....	.....	.....	.....	.....	30,017,606	1880
.....	.....	.....	.....	.....	.....	.....	31,992,797	1881
.....	.....	.....	.....	.....	.....	.....	35,704,288	1882
.....	.....	.....	.....	.....	.....	.....	30,255,479	1883
.....	.....	.....	.....	.....	.....	.....	35,968,741	1884
.....	.....	.....	.....	.....	.....	.....	36,764,730	1885
.....	.....	.....	.....	.....	.....	.....	47,243,154	1886
.....	.....	.....	.....	.....	.....	.....	47,807,083	1887
.....	.....	.....	.....	.....	.....	.....	52,164,597	1888
94,250	.....	.....	.....	.....	.....	.....	61,507,095	1889
118,065	.....	.....	.....	.....	.....	.....	76,632,838	1890
190,131	.....	.....	.....	.....	.....	.....	91,100,347	1891
242,284	.....	.....	.....	.....	.....	.....	88,739,219	1892
298,969	600,000	.....	.....	.....	.....	.....	92,038,127	1893
327,218	688,170	.....	.....	.....	.....	.....	89,335,697	1894
371,536	1,215,757	.....	.....	.....	.....	.....	103,562,510	1895
429,979	1,427,132	47,536	.....	.....	.....	.....	114,159,183	1896
545,704	2,551,649	70,831	.....	.....	.....	.....	121,948,575	1897
542,110	2,964,035	70,905	.....	.....	.....	.....	124,924,682	1898
940,971	1,795,961	89,166	.....	.....	.....	.....	131,143,742	1899
1,078,264	2,253,355	274,800	.....	.....	.....	(a)	149,132,116	1900
1,430,716	4,013,710	274,800	.....	.....	.....	20,000	167,424,089	1901
1,617,363	2,430,465	286,725	.....	.....	.....	26,000	181,965,876	1902
2,510,259	5,770,056	278,092	.....	.....	.....	36,000	194,804,294	1903
3,385,468	6,508,485	345,834	220,653	.....	.....	40,000	218,299,419	1904
4,137,098	7,849,896	447,880	320,379	.....	.....	30,000	215,361,296	1905
4,015,803	8,180,657	536,294	1,097,264	.....	.....	30,000	214,010,124	1906
4,344,162	9,982,597	756,226	1,717,690	.....	.....	30,000	264,958,008	1907
5,047,038	10,283,357	1,011,180	3,481,610	169	.....	41,000	285,089,984	1908
6,676,517	11,041,852	1,316,118	2,488,742	57,143	.....	38,000	298,373,216	1909
6,137,990	11,030,620	1,330,105	3,332,807	142,857	.....	40,700	327,615,603	1910
6,451,203	12,172,949	1,368,274	14,051,643	285,307	9,150	33,000	345,685,081	1911
7,116,672	10,845,624	1,751,143	16,558,215	436,805	205,905	67,000	352,484,591	1912
7,930,149	11,966,857	2,133,261	25,902,439	503,616	94,635	150,600	384,667,550	1913
6,190,476	(b)12,705,208	1,917,802	21,188,427	643,533	777,038	295,000	399,264,168	1914
6,833,333	(b)12,386,808	2,487,251	32,910,508	(a)750,000	262,208	526,000	426,370,894	1915
7,076,161	(b)13,174,399	2,489,458	39,817,402	928,581	411,000	820,000	459,433,319	1916
6,732,370	(b)12,928,955	2,533,417	55,292,770	1,599,455	1,008,750	8,149,710	506,362,665	1917
6,823,453	(b)13,284,936	2,458,376	63,828,327	2,082,068	2,079 750	10,763,395	515,546,481	1918
8,453,800	(b)15,780,000	2,561,291	87,072,954	2,780,000	1,662,184	12,142,600	559,101,644	1919
7,500,000	17,529,210	2,816,649	163,540,000	2,083,027	1,042,000	15,887,114	694,380,400	1920
6,864,000	18,000,000	3,568,000	195,064,000	2,354,000	1,181,000	18,823,000	759,030,000	1921

(c) Includes Persia, Scotland, Argentina, Venezuela, etc.
(e) Alsatian field production appears under Germany to 1919 and then under Other Countries.

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of the Rock Springs anticline, in the central part of the county. Here also, however, prospecting is difficult and expensive, and the value of the folds even if discovered is problematic.

One of the most significant facts shown by the map is the coincidence between the oil and gas fields and the anticlinal folds. Such fields as are not on pronounced anticlines have as a rule yielded only a small output. The foolishness and uselessness of random drilling without respect to the location of anticlinal folding could not well be better demonstrated. The Osage field, in Weston County, is an apparent exception, but as a matter of fact this field and other small producers along the western margin of the Black Hills show a very distinct relation to structure, although it is not anticlinal structure, and geologists can be of quite as great assistance in selecting areas for prospecting in this region as in the regions of more intensely folded beds farther west.

Extravagantly worded literature issued by promoters frequently uses the location of properties on or near some well-known anticline as an argument for certain success. The map shows that the majority of the anticlines of the State are not productive of oil, although the oil that is found is almost always associated with anticlinal structure. The number of producing oil fields is but 17 per cent. of the number of anticlines shown on the map.

The fact that only a tiny portion of Wyoming is actually yielding oil is strikingly brought out by this map. There are large areas where not only no oil has been discovered, but where even the details of geologic structure which may indicate the existence or absence of oil are unknown, and there remains ample room in the State for both prospector and geologist to develop new and almost unsuspected fields.

Early in 1922 the Secretary of the Interior announced that a lease had been made with the Sinclair interests of the Teapot dome, south of the Salt Creek field. The terms of the lease give the Government from one-eighth to one-fourth of all the oil, and the right to purchase the fuel-oil portion if desired. The lease also stipulates that drilling shall proceed if necessary to 3600 ft. The construction of a pipeline from the field to Mid-Continent markets is a feature of the lease. Altogether the lease is a most favorable one for the Government, especially considering that the dome is still wildcat territory.

The Oil Supply of the World

The following is an abstract of a paper by David White presented at the Engineering Congress on the Petroleum Industry at Kansas City, Mo., Mar. 6, 1922:

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The question is often asked, Why is the United States, whose petroleum market is now depressed because of a slight excess of oil supply, especially concerned about how much oil there is in our own country and the world? The concern of the public in the economic problem of oil supplies arises from the following outstanding features of the situation, which give the question an incisive significance to every American user of oil:

The United States has furnished nearly two-thirds of all the oil yet taken from the ground in the world—5.5 billion barrels out of a total of 8.5 billion. American fields are now pouring out 62 per cent. of the world's annual supply, while our country is using over 75 per cent. of that total supply. In other words, the United States requires over 115 million barrels more than it produces. Our output now approximates 470 million yearly, but our requirements, even during the business stagnation of 1921, called for 525 million.

Where will the oil to satisfy these requirements come from? How long can we keep up the pace? These are plain, common-sense business questions, predicated on our present oil requirements as an established fact and on the suggested possibility that our prodigal spending of our petroleum heritage may cause its too rapid depletion if not its early exhaustion in the midst of our spendthrift career, and at some untoward moment send us as beggars to foreign countries for the precious fluid necessary not only to satisfy our extravagance but even to sustain our industrial prosperity, our standards of living, and our civilization.

Obviously, the first thing to be done is to take account of stock, to find out how much oil there is left in the United States, and then to learn as nearly as possible how much oil there is in the rest of the world and where the principal deposits or reserves are situated, due consideration being given to probable availability and conditions of production of these reserves.

The oil reserves to be found in the regions of the earth where oil has already been proved to exist in commercial amounts were estimated in 1920 by Eugene Stebinger and myself at 43 billion barrels. The consideration of the geology of other regions in which oil has not yet been proved to be present in commercial amounts led to an additional estimate of 17 billion barrels, a total of the world's oil reserves in the ground and recoverable by present methods of 60 billion barrels. I am disposed to regard an estimate of 70 billion barrels for the world's total resources as conservative.

The most important oil regions outside of the United States are believed to be in Mexico, Venezuela, Colombia, Bolivia, Argentina, Russia, Mesopotamia (together with western Persia), Assyria and Arabia, the East Indies, China and eastern Siberia (including northern Sakhalin), the Japanese Empire, India, and probably northern Africa.

Inaccessibility of the oil regions, lack of transportation and other industries essential to oil exploitation, and remoteness from all important markets, will deter for long periods the discovery as well as the development of many of the oil fields in both hemispheres. Further, periods of glutted markets may recur, but it seems to me more probable that, in general, oil-field development is likely to be led by competitive demands arising from the inevitable enormously expanding world markets.

In the United States we have at the present moment produced a total of 5½ billion barrels of oil—more than one-third of our estimated original heritage of oil. Contrasted with our more than 5-per cent. rate of annual depletion, the rest of the world withdrew in 1921 not much over 280 million from its store of over 60 billion barrels, or less than one-half of 1 per cent. of its reserve recoverable by present methods. In other words, the reserves of the rest of the world would stand the present rate of drain

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for over two centuries. From the standpoint of the world distribution of oil and the economic relations of our reserves to those of the rest of the world, an error of two or three billion barrels—four to six years' supply—in the estimate of the oil reserves of the United States, is comparatively insignificant.

The co-operative committee expressly affirms that not all the oil pools in the United States will have been discovered a generation hence. On the other hand, the committee takes great pains to point out that though our reserves would not meet our present rate of consumption demands for 20 years, if they could be taken out of the ground fast and cheaply enough to supply our market (a conditioning clause that has generally been lost sight of by the press and the public), this country will be producing oil for as long as 75 years to come.

As oil cannot so rapidly be located and taken from the ground, it follows with certainty that, according to the laws of oil production, the annual oil output of the United States must at an early date pass its peak and enter upon a long-drawn-out period of general though fluctuating decline to ultimate exhaustion; except so far as fields in great numbers may be rejuvenated by better methods of mining. Opinions differ as to how soon the production peak will be passed, but most geologists believe that within a few years, perhaps less than five, we shall in the normal course enter on a period of waning fields in increasing numbers, with discoveries more infrequent and in general more costly.

A large portion of the public does not yet fully recognize that the United States is already dependent upon foreign oil to meet its still growing requirements. Our oil importations, 18 million barrels in 1913, grew to 38 million in 1918, 53 million in 1919, 106 million in 1920, and 125 million in 1921. A small part only (less than 9 million) of this amount is offset by exportation of crude petroleum from the United States. In short, in a period of industrial depression, we have imported one-fourth as much as we produced. Nearly all of this oil comes from Mexico, and that is why Americans are so profoundly interested in Mexican oil.

The present production in Mexico, amounting to about 195 million barrels in 1921, is mostly drawn from a relatively small number of wells situated along a single axis of folding in which a thick limestone, the Tamasopo, is caverned by solution and, in the structurally high points, gorged with gas and oil under most tremendous pressure of salt water. No wells of such enormous production are known in any other part of the world. It is practically certain that, though some new discoveries of Tamasopo oil may come to the aid of the rapidly failing pools, sooner or later the production of oil from world-record-breaking Tamasopo limestone gushers will wane, and the remaining portion of Mexico's 4 to 5 billion barrels of oil reserves, as estimated, must be won by the sweat of the oil operator's brow from wells of the ordinary type.

The magnitude of the task of developing enough oil fields of the "common or garden variety" in Mexico to take over the load of an annual production of 195 million barrels, which was produced from less than 300 wells in 1921, may be inferred from the fact that in 1908, when for the first time the production of oil in the United States amounted to so much as 175 million barrels, over 140,000 wells contributed to that output. This number is, of course, subject to radical discount for rapidity of development and freshness of production. It would take over ten Haynesvilles or a group of four Mexias or fourteen Salt Creeks, all running full blast, simultaneously, and all continuously maintaining their January rates of production, which, of course, is impossible. It is difficult to estimate the oil price stimulus necessary to develop a production of 200 million barrels of oil in Mexico from wells of the ordinary type under existing transportation, climatic, and industrial conditions, within five years. The

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prices requisite would certainly be most encouraging for the production of oil from shale in this country.

The collapse, or, better, the great slump in Mexican production which seems, sooner or later, inevitable, can hardly fail to react on our own oil-field production, probably driving it to the limit; and it is likely that in the early period of this strain the annual output of petroleum in the United States will pass its peak. Beyond this point our need for more foreign oil is likely to spring from our decreasing domestic production more than from further growth of our consumption requirements. In this period relief must come from other foreign oil fields and from the production by distillation of shale oil, on whose adequacy and on whose yet undetermined cost we may be obliged to rely for protection against transoceanic importation at transoceanic prices beyond our control. Too great an advance in price will, of course, check our use of oil and bring it nearer within the bounds of practicably available supplies from all sources, at prices then viewed as practicable. The oil we cannot afford to buy we will do without.

Among the constructive economic deductions to be drawn from a review even so superficial and elementary as this summary of the high points of the situation as to oil resources it is to be seen that:

1. The need of foreign oil reserves available for continued use in the United States is obvious.

2. Waste in producing, in transporting, and in using oil should be prevented or curtailed as far as economically practicable. The problems are insistently pressing. Large results are known to be immediately possible.

3. Increased concentrations of thought and experimentation on the more efficient use of the oil now available and on the production of commodities of greater efficiency are economically urgent. On every occasion consideration should be given to the general abandonment of oil to generate steam, in favor of the three times as efficient Diesel motor or some other still more effective substitute.

4. More intense and more widespread researches in the production of liquid hydrocarbons through processes—so-called low-temperature carbonization—aimed at the more efficient use and the wider adaptation of our bituminous and lower-grade coals, are important.

ESTIMATED OIL RESERVES OF THE UNITED STATES, BY STATES OR REGIONS

	Millions of Barrels.
New York	100
Pennsylvania	260
West Virginia	200
Ohio	190
Indiana and Michigan	70
Illinois	440
Kentucky, Tennessee, northern Alabama, and northeastern Mississippi	175
Missouri, Iowa, North Dakota, Wisconsin, and Minnesota	40
Kansas	425
Oklahoma	1,340
Northern Louisiana and Arkansas	525
Texas, except Gulf Coast	670
Gulf coast, Texas and Louisiana	2,100
Colorado, New Mexico, and Arizona	50
Wyoming	525
Montana, Nebraska, and South Dakota	100
Utah, Nevada, Oregon, Washington, and Idaho	80
California	1,850
Eastern Gulf Coastal Plain and Atlantic Coast States	10
	9,150

5. The development on a commercial scale of an oil-shale industry deserves more earnest and wiser consideration. The deposits of rich shale in Colorado, Utah, Wyoming, and Nevada alone are sufficient, if fully used, to generate more than seven times

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the oil estimated to remain in the ground in the United States recoverable by present methods.

6. The recovery of a much larger portion of the oil in the reservoir rocks than is obtained by present methods is an imperative necessity, demanding the faithful, the intelligent, and the immediate consideration of the states and of the Government as well as of the oil industry.

Foreign Countries

North America

Canada.—From practically complete returns covering the production of petroleum in all provinces, the output for the Dominion was computed to be 190,000 bbl., valued at $580,842, an average of $3.05 per bbl. The total production of crude oil in 1920 was only 6000 bbl. higher, but the value reported was considerably in excess of that for 1921, amounting to $822,235.

The production of New Brunswick in 1921 amounted to 7479 bbl., of which 6300 bbl. was sold for $24,500.

The production of petroleum in Alberta is estimated at 11,000 bbl. for the year, which according to an average taken from reports received from this province, would be worth in the neighborhood of $76,000.

Ontario was as usual the principal producer, and during the year a total of 172,859 bbl. was produced, valued at $468,447, an average of $2.71 per barrel.

The production, in barrels, in the various fields in the provinces of Ontario, as kindly furnished by the Supervisor of Petroleum Bounties at Petrolia, was as follows:

Field.	1919.	1920.	1921.
Petrolia and Enniskillen	70,087	65,061	68,484
Oil Spring	45,245	39,388	40,967
Moore township	.....	7,036	7,536
Sarnia township	.....	3,495	4,069
Plympton township	.....	531	481
Bothwell	29,425	26,564	26,877
Tilbury East	18,365	623	1,003
West Dover	.....	12,171	7,473
Raleigh township	.....	489	3,320
Dutton	1,272	837	.....
Onondaga	197	341	566
Mosa township	45,860	24,036	10,764
Thamesville	801	1,131	1,320
Total	211,252	181,723	172,859

A bounty of $90,751 was paid by the Government on the 1921 production, giving it a total value to producers of $559,198.

Exports of petroleum entered as crude mineral oil in 1921 were 5,384,751 gal. valued at $375,820, and of refined oil 1,466,422 gal. valued at $209,282. There was also an export of naphtha and gasoline of 762,080 gal. valued at $212,638, and an export of mineral wax amounting to 16,420 lb. valued at $7,552. The exports in 1921 were: Crude oil,

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2,684,427 gal. valued at $293,325; and of refined oil, 1,243,335 gal. valued at $205,999; naphtha and gasoline, 160,433 gal. valued at $59,432.

The total value of the imports of petroleum and petroleum products in 1921 was $37,487,807, as against a value of $48,587,123 in 1920, and a value of $29,519,196 in 1919. The total quantity of petroleum oils, crude and refined, imported in 1921 was 472,744,572 gal., as compared with 442,824,635 gal. in 1920 and 451,211,270 gal. in 1919.

The keenness of interest displayed for the past two years in the find of petroleum at Fort Norman, in the extreme north, may well be taken to forecast definite growth in the Canadian oil industry within the next few years—growth consistent with the latent supplies, which have been well described by Clapp in his report of several years ago to the Canadian Government, and well summarized by him in Day's "Handbook of the Petroleum Industry" just issued. That the Fort Norman locality will be the first locality to receive serious consideration is doubtful—any consideration of it is too serious at present. It is well understood, however, that the world search for oil supplies more accessible than the north-pole territory have extended thoroughly over Canada, and the time for intensive development waits merely on that crisis in the oil trade which must follow a decline in Mexican production.

Rather than to spoil by condensation the flood of literature that has followed the Mackenzie River excitement, let the reader refer to a timely resumé of Canada's oil history in the *Canadian Mining Journal* of Dec. 9, 1921, taken from the *Imperial Oil Review;* also "The Pouce Coupe Oil Field," by E. L. Chicanot, in the *Canadian Mining Journal* of Dec. 9, 1921. Ronald C. Campbell-Johnston has described the western Canada conditions in the *Mining Journal* of Sept. 24, 1921, and following numbers. The Mackenzie River Valley is treated with good illustrations by Kindle and Bosworth in the *Canadian Mining Journal* of Aug. 12, 1921, and Arthur H. Redfield accompanies his article in the *Engineering and Mining Journal* of May 21, 1921, with a good bibliography of the whole subject.

It is to be wished that the subject of the tar sands of the Athabasca River should receive equally thorough treatment, for it looks as if the thorough and painstaking researches of Ells for the Canadian Bureau of Mines into the actual distribution of oil in these sands are about to culminate in large-scale utilization, probably by an American organization.

Mexico.—A mere statement of the total production of oil in Mexico in 1921—195,064,000 bbl.—is sufficient to point out the prominence which that great supply has obtained. In 1920 the output was 163,540,000 bbl. Of the product the greater part goes to large refining companies in the United States, notably to the Standard Oil Co. of New Jersey. These

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companies dominate in the trade not only by adequate refining facilities, but by intelligent use of the available transportation facilities.

The following table shows all of the Mexican oil fields discovered up to June 1, 1921, with the date of discovery, number of wells drilled, number of productive wells, and the production of these wells:

NUMBER AND PRODUCTION OF WELLS IN MEXICAN OIL FIELDS

Regions and Fields.	Year Discovered.	Number of Wells.		Production.	
		Drilled.	Productive.	Total, Barrels.	Present Average Daily, Barrels.
Panuco, Topila, and Ebano fields:					
Panuco	1910	218	112	121,000,000	127,000
Topila	1910	75	18	8,539,000	3,500
Ebano	1901	71	38	22,400,000	4,000
Total				151,939,000	134,500
South fields:					
Tepetate and Upper Chinampa	1910	28	17	126,874,000	(a)
Lower Chinampa and Amatlan	1913	89	43	141,566,000	240,000
Zacamixtle	1920	10	8	12,039,000	50,000
Toteco	1921	3	3	1,000,000	30,000
Cerro Azul	1916	6	2	59,002,364	60,000
Potrero del Llano and Alazan	1910	21	11	115,650,000	(a)
Tanhuijo and Tierra Amarilla	1910	39	21	500,000	(b)
Alamo	1913	9	6	35,803,806	15,000
Molino	1917	2	1	11,000	500
Total				492,446,170	395,500
Tehuantepec region	1904	220	54	7,000,000	
Miscellaneous				500,000	200
Grand total				651,885,170	530,200

(a) Salt water. (b) Abandoned.

The field record during 1921 has been one of large gushers rather than a large number of wells drilled. These gushers have more than sufficed to maintain production in spite of the fact that the expected inroads of salt water have been more than realized. The situation persists, therefore, of great uncertainty as to the immediate future. The American industry is on the *qui vive* for a sudden decline in the output, with a correspondingly sensational effect upon prices in the United States and upon the whole course of search for new fields. Particularly the dormant shale industry waits upon Mexico. Meantime the Mexican industry has kept on with the necessary large-scale development of huge tank farms, pipelines, and harbor facilities. Refining has held back somewhat, but negotiations are being driven by the Mexican Government towards some rational national utilization of the oil at home. This is seen in the unsettled condition of Federal taxation problems. These after several important conferences between the Mexican Government and the chief oil purchasers in the United States only reached a definite solution in 1922.

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The abundant literature of 1921 on the petroleum resources of Mexico displays very optimistic views opposed to equal pessimism as to the future. The former are clearly stated by Roy H. Flamm in the London *Mining Journal* of Nov. 26, 1921, while the equally definite expressions of Dr. Ralph Arnold, chairman of the oil and gas committee of the American Institute of Mining and Metallurgical Engineers, speak for quick exhaustion.

Central America

Panama.—Evidences of petroleum occur on both the Caribbean and the Pacific coasts. Seepages of oil are reported off the shores of San Miguel, near the Tonosi River, along the Gulf of Montijo; and along Mosquito Bay gas has been found in a well near Bocas del Toro. Authority exists for concessions. The principal one thus far granted is to the Sinclair Panama Oil Corporation to explore an area of 11,000,000 acres, with the right to select 1,200,000 acres. The concession of exploration of the Chorcha Co. has been leased by a New York concern.

In a report dated July 30, 1921, U. S. Consul George Orr, at Panama City, states that concessions have recently been obtained by two American oil companies for carrying on operations in Panama. Considerable exploration work has been done, but no oil deposits have yet been located. Legislative enactments canceling certain privileges originally granted to the concessionaires have resulted in practically suspending active operations.

West Indies

Trinidad.—Trinidad produced 2,354,119 bbl. of petroleum in 1921, compared with 2,083,027 bbl. in 1920, according to the Director of Lands and Mines.

The following is the report of Consul Henry D. Baker, published in a supplement to *Commerce Reports*:

Although the agricultural industries of Trinidad afford the main basis for the colony's prosperity, yet the production of asphalt and of petroleum contribute very extensively to the wealth of the colony, and the increasingly extensive operations of petroleum oil companies have added a stimulus to general business.

The shipments of crude and fuel oil, according to the report of the local collector of customs, declined from 44,681,107 gal., valued at $2,637,739, in 1919 to 31,905,838 gal., valued at $2,056,252, in 1920, a decrease of 12,775,274 gal. in quantity and $581,487 in value. Shipments of petroleum spirit were also lower in value during 1920, the figures being 2,420,821 gal., valued at $667,414, as against 2,419,744 gal., valued at $706,996, in 1919. There were no shipments of the above oils other than of local production. The inspector of mines of the Trinidad Government, in his recently issued annual report, states that there were considerable stocks of oil still awaiting export at the close of the year 1920. The harbor master of Trinidad reports that

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during the year 1920, 218 ships bunkering here took in 13,519,148 gal. of fuel oil. For 1919, he reported that 150 vessels took 9,707,047 gal. of fuel oil. The export returns for the colony do not include fuel oil supplied to vessels bunkering locally.

Toward the latter part of 1920, as also thus far in 1921, the demand for oil products has shown considerable abatement and local companies at present have large unsold stocks on hand. During the year 1920, 67 new wells were drilled in Trinidad, an increase of 14 over the previous year. In 41 of these new wells, oil was struck.

South America

Argentina.—During the year 1920 1,540,492 bbl. of crude petroleum was produced from the Comodoro Rivadavia field, according to a report of Edward Fesly to the Department of Commerce. The production was hampered by a strike during the early months. The rate increased from 86,000 bbl. a month at the beginning of the year to 160,044 as the average rate of the last 4 months. The quality of the oil showed a slight improvement, but it is heavy black oil and contains enough water to require occasional rebates. There is a dehydrating plant which is to be increased in capacity. There is talk of a refinery at Buenos Aires. In 1921 the rate of production increased 2,000,000 bbl. The field is described in detail in *Commerce Reports* of July 24, 1921, and Aug. 1, 1921.

The occurrence of petroleum in Salta and Jujuy provinces, in northern Argentina, are well described by Trade Commissioner Brady in *Commerce Reports* of Oct. 3, 1921.

The Mendoza-Neuquen oil region is the oldest of the Argentina fields. It has been worked on a small scale continuously since 1886. Last year more favorable results of Neuquen renewed general interest. Oil rights have been granted to several foreign companies, and larger development is looked for. Neuquen oil is black; that from San Rafael in Mendoza is brown. It is low in sulphur and is rich in gasoline. A general description of the field can be obtained from the Department of Commerce, Washington, D. C.

Ecuador.—The principal petroleum developments in Ecuador are those of the Santa Elena fields on the west coast. There are five drilled wells and many open wells. The Anglo-Ecuadorian Oil Fields, Ltd., have new machinery with which they plan to drive five more wells in 1922 to prove up the fields. The quantity of crude oil produced is about 4000 bbl. per month. The product of the open wells is of much lower grade than that of the drilled wells, the latter being of exceptionally high grade. No accurate figures are available, but it is known that all of the crude product is consumed locally, there being two small refining plants in the district, where kerosene and gasoline are produced. A recent discovery of oil shale and petroleum was also made in a district north of Guayaquil and more than from the Santa Elena fields.

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According to Consul General Frederic W. Goding, the Government of Ecuador has drawn up a contract with a representative of an American company interested in the development of petroleum deposits which provides for permission to exploit such deposits in the Province of El Oriente. The company is under obligation to expend $5,000,000, and to construct three good public highways to communicate with the sparsely inhabited oriental region where it is to be located. The period of exploitation will be 34 years.

Guatemala.—Sufficient reports of seepages have been made and favorable structural conditions found to induce much exploration, though no drilling has yet begun. Arthur H. Redfield has described the conditions in detail.[1]

Peru.—The oil fields of Peru yield more oil than those in any other South American country. In 1920 the product from the five fields Lobitos, Negritos, Zorritos, Pusi and Lagunitas aggregated 2,790,000 bbl. The fields are thoroughly described in an article by Vernon F. Marsters.[2]

Venezuela.—According to Consul J. O. Sanders, serious attempts to exploit the petroleum resources of the Maracaibo district began shortly before the World War, but such exploitation on a large scale dates from the latter part of 1920. The year 1921 marked the active advent of seven important oil companies into the field. The total expenditure of money within the country by oil interests in this district is estimated to have been $400,000 a month during the year, and $100,000 a month was spent for material and supplies imported from without the country, all but a negligible portion of which came from the United States.

Only one company produced oil during the year, but there were nine producing wells brought in, bringing the total producing wells in the district up to 15. Owing to lack of necessary equipment, however, only 10 of these wells were being exploited at the close of the year. All stages of the oil business—exploring, surveying, drilling, and producing—were in progress during the year and this condition is expected to continue during 1922.

The economic factors affecting the oil business in the Maracaibo district can not be said to be favorable. The shallow bar at the entrance of the lake and the lack of public highways and railways add greatly to the cost and delay in moving tools and supplies into the new fields of operation. Considerable attention and expense is required to make a new camp sufficiently sanitary to protect the health of the employees, most of whom are not accustomed to life in the Tropics.

The methods of development are those commonly seen in a compara-

[1] *Eng. Min. Jour.*, Oct. 1, 1921.

[2] *Eng. Min. Jour.*, June 25, 1921.

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tively new oil field. The firm that has already reached the producing stage installed during the year the necessary equipment for collecting and treating the escaping gas from its wells. This will save a product which would otherwise be lost and at the same time reduce the chances of loss by fire. Labor conditions are reasonably stable and generally favorable. Peon laborers are plentiful at a wage of 5 bolivars (about $0.90 at present rate of exchange) per day. Practically all skilled labor is imported, mainly from the United States.

The production of the Maracaibo district during 1921 was 219,929 metric tons. Of this sum, 151,158 metric tons was exported and 68,771 metric tons consumed in Venezuela. The exports went to Curacao and the rest was treated in the refinery located near the producing fields in this district and then marketed as gasoline, kerosene, fuel oil, etc.

This refinery is owned and operated by the Caribbean Petroleum Co., a Dutch Shell concern incorporated in the United States. A comprehensive survey of the petroleum industry in Venezuela was published in *Commerce Reports* for Feb. 14, 1921.

Attention is called to the general description of the oil resources of South America by Henry B. Miller in the *Mining Magazine* of April, 1921.

EUROPE

Czecho-Slovakia.[1]—A writer in *L'Information* gives the following particulars relating to the petroleum industry in Czecho-Slovakia. The deposits at present located lie along a line running from Lundenburg to Moravska-Ostrava, and thence follow in an easterly direction the chain of the Carpathians, almost entirely on Polish territory. The most important are the Gbeli deposits, in western Slovakia, with a daily production of two tanks of heavy oil, used principally for the preparation of lubricating oils. In the month of January, 1921, borings carried out by the Schodnica company near Goding are stated to have met with naphtha at a depth of 217.5 meters, the oil being similar to that of the Gbeli wells, with a large proportion of paraffin. The right to search for oil and develop the deposits is reserved by the Government, who, however, are prepared to grant permits on certain conditions. At present practically all the crude oil required for the refineries is imported; according to figures published for the period Jan. 1–Oct. 15, 1920, 2150 tanks were imported from Roumania, 1910 tanks from America, and 1300 tanks from Poland. There are 7 large refineries, 3 being situated in Bohemia, 2 in Moravia, 1 in Silesia, and 1 in Slovakia, their total capacity in crude oil being given as 400,000 tons per annum; the actual production of refined oils is, however, not more than 226,747 tons. The most important refineries are the

[1] *Min. Jour.*, Aug. 27, 1921.

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Pardubitz (Société de Pétrole Fanto); the Oderberg (Budapester Mineraloelraffineries A. G.); Apollo (Bratislava), controlled by the Dabrowa group; Kralupy (Lederer & Cie); Mahr-Schonberg (Société Française des Pétroles Premier); Oderfurt (Oderfürter Mineraloelwerke); Kolin (Société de Pétrole de Kolin). There are also smaller concerns at Trsztena (Dutch group), Marton, Kosice, Ormezo, and Zilin.

France.—Petroleum production of France from the Basin of Pechelbronn, Alsace, in 1921, was 55,575 metric tons (392,360 bbl.), according to the Director of Mines, Department of Public Works. Production in 1920 was 54,900 tons (338,700 bbl.).

Poland.—According to Dr. Stefan Bartoszewicz, the production of crude oil in Poland in the year 1921 amounted to 704,870 metric tons, out of which 630,440 tons (89.4 per cent. of the total) was obtained in the district of Drohobycz, whereas the district of Jaslo produced 50,570 tons (7.2 per cent.) and the district of Stanislawow 23,860 tons (3.4 per cent.).

The production of crude oil for the last three years in the said districts was as follows:

Year.	Drohobycz, Tons.	Jaslo, Tons.	Stanislawow, Tons.
1919	758,840	51,720	21,140
1920	690,770	49,320	24,930
1921	630,440	50,570	23,860

From the above table it will be seen that although the production of crude oil in the districts of Jaslo and Stanislawow has undergone some slight changes (in the Jaslo district has even increased in comparison with 1920), the production in the richest district of Drohobycz has been steadily decreasing, and the decrease amounts to 9 per cent. per year. The chief reason for this is that the principal oil center of Boryslaw and Tustanowice is getting gradually exhausted and the productiveness of oil wells from year to year is becoming smaller.

The drilling activity that is concentrated only in the southern part of Boryslaw and Mraznica has even increased in the year 1921, in which the number of wells being drilled increased from 153 to 225. Up to now no results have been shown, as, on the average, three years must elapse until the sinking of a well to the depth of 1400 meters (where greater quantities of crude oil are to be found) is carried through.

A greater drilling activity in the district may in the future prevent the further falling-off of production. As far as an increase of production is concerned, this can only take place when fresh oil-bearing territories are subject to development. There are still in Poland many oil territories promising the existence of productive wells.

The average productiveness of Polish oil wells is still becoming smaller in consequence of the fact that the sinking of wells is taking place in the

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neighborhood of old mines, where couches of oil are more or less exhausted.

In Poland in 1919, 1637 wells were in development; in 1920, 1720; and in 1921, 1728. The average production per well in 1919 amounted to 508 tons per year; in 1920, to 445 tons; and in the last year only 409 tons.

The production of natural gas in 1921 was 400,304,000 cu. m., and in 1920, 404,973,000 cu. m., which means 768 cu. m. per min. The gas production has therefore been subject to a very small decrease.

It must be pointed out that out of 704,870 tons produced, over 60,000 tons was burnt at the mines, and nearly 60,000 tons represented the mancos and uncleaned products, in consequence of which the amount of 585,640 tons was left for the refineries.

Polish refineries have refined the whole of the crude-oil output, as well as the balance left from previous years, totaling 627,000 tons, out of which 571,670 tons of oil products was received. The amount of 208,090 tons was used for local consumption and 333,649 tons was exported, the balance being stored in the refineries.

Polish oil products are chiefly exported to Austria, Germany, Czecho-Slovakia, and Jugo-Slavia. During last year the exportation via Danzig has greatly fallen, though oil products were exported to Sweden, Norway, Finland, Latvia, Great Britain, and even Italy.

The oil industry of Poland has recently undergone a beneficial change, because governmental restrictions, formerly so severe, have been modified for domestic and export trade. Formerly the Ministry of Commerce and Industry controlled all domestic and foreign deliveries and prices. Now the Ministry pro-rates among the refineries the Government's needs and the rest may be sold anywhere. The Government no longer fixes the maximum price.

A detailed review of the Galician petroleum industry is given in the London *Petroleum Times* of Apr. 15, 1922, by Mr. Albert Millar.

Roumania.[1]—The production of crude oil in Roumania for each month of 1921, compared with the same period of 1920, was as follows:

	1921, Metric Tons.	1920, Metric Tons.
January	97,825	70,028
February	82,724	66,354
March	93,165	79,149
April	97,601	90,735
May	99,368	78,436
June	79,722	79,757
July	83,694	83,313
August	106,217	99,005
September	102,338	99,960
October	112,311	91,098
November	105,920	101,248
December	100,000	94,934
Total for the year	1,160,885	1,034,017

[1] *Eng. Min. Jour.*

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The increase in production over the preceding year was about 125,000 tons, or 12 per cent. It is equal today to about 60 per cent. of the pre-war production, when during 1913, the record year, 1,885,617 metric tons of petroleum was produced.

The industry is slowly recovering from the destruction brought about by the war. Indeed, it is a matter of record that during the winter of 1916 the oil wells were completely destroyed by the Allies, to prevent the large quantity of oil, badly needed by the Germans, from falling into their hands. Notwithstanding the strenuous efforts which the invaders made to repair the wells, they were unable to produce more than 527,491 tons in 1917. Nevertheless, in 1918 the output was 1,214,219 tons, and the Roumanians have not been able, up to date, quite to equal this total.

The principal causes responsible for this situation were of three different orders: First, materials difficulties, due to lack of proper and regular means of transportation. Materials can be only slowly, at enormous cost, and with great pains sent by rail to Roumania, on account of the chaotic situation of the railroads in the neighboring countries—Hungary, Czecho-Slovakia, and Poland. On the other hand, for the maritime transports, only two ports, Braila and Galatz, can be used, and conditions are unfavorable, because these harbors are usually blocked by ice during several months in winter, and are lacking in modern and powerful equipment to handle the merchandise after its arrival.

Worst of all, in Roumania itself, the traffic facilities of the national railroads are utterly insufficient. The country has at its disposal neither the cars nor the engines which it needs to carry from the harbor to the oil fields the general supplies which must come from industrial countries, like the United States, England, France, Belgium, and Germany. Production on the fields often has had to be limited because all available tanks were entirely filled. Producers could not ship the oils to the refineries or consumers, because they had no tank cars, and the pipelines were not operating, or, if so, only at a reduced capacity.

In the fields where power is dependent on electricity operations have been greatly handicapped, and even suspended for weeks, by the frequent failure of the powerhouse of the electrical company of Campina, which supplies the greater part of the current used.

The sinking of new wells is entirely dependent on the material which operators can buy abroad, and purchases and replacements are rendered exceedingly difficult by the low rate of exchange on Roumanian money. This financial difficulty is greater today than ever before.

The last, but not the least, cause of reduced output and difficulty in production which has handicapped the progress of the oil industry in Roumania is the continual interference of governmental regulation in

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the oil business. This has operated along three lines: fixation of maximum prices—but not in accordance with the producing cost—for the oil sold inside the borders of the country; limitation of the quantity which could be exported, and heavy taxation on the product sold on the foreign markets. Against all these difficulties the oil producers of Roumania have done their utmost, and they have not succeeded so badly, if one considers that the results obtained surpass by far those that have been possible in all other kinds of Roumanian industries.

The country as a whole is taking great interest in the oil business. National capital investment is much more largely represented in this branch of activity than it was before the war. The total nominal capital of all the companies is 2,650,000,000 lei,[1] on which 2,273,000,000 have been paid. The increase during the last year alone has not been less than 950,000,000 lei, and it will not be surprising to learn that this increase has been the largest ever recorded in the Roumanian petroleum industry.

The prospects for the future are encouraging. The pipelines are operating more satisfactorily; the railroads have bought some equipment, and the great harbor of Constantza, which is open all the year round, can be used regularly. Indeed, the large Carol bridge, on the Danube River, which was destroyed during the war, has been repaired and reopened.

In an effort to improve existing power conditions, the Steaua Romana, one of the largest operating companies, is building a powerhouse in Floreshti, which will furnish electrical current, conjointly with the centrals of Sinaia and Campina, to the oil fields of the Prahova district. It is expected that the new electrical plant will be in operation next summer. It cost 50,000,000 lei, and will be able to produce 6300 kilowatts. Arrangements are provided to carry its capacity to 24,000 kva.

The number of wells now being drilled is 264, of which 30 are using rotary apparatus; 20 are being water-flushed, 14 are using cable tools, and 200 possess Canadian-Galician outfits. The number of producing wells is about 700.

Russia.—The Bureau of Foreign and Domestic Commerce in *Commerce Reports* of Feb. 27, 1922, published the following with regard to the production of oil in the Baku oil fields:

> The gross output of the Baku oil fields continued on the increase and the general conditions manifested a certain tendency toward stabilization. There is, however, according to the Bolshevist press, still a grave shortage of certain indispensable materials, of food and other means of maintenance for the men, proportionate to their increased earning capacity, and of operating funds.

[1] The lei was before the war rated as equivalent to 19⅓ cts. United States currency.

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The total output for the year 1921 was 2,519,290 long tons, of which 668,760 tons was produced in the last quarter, as compared with 622,900 tons in the first quarter, 659,100 tons in the second quarter, and 568,530 tons in the third quarter.

The larger output for the first half-year was largely accounted for by the gusher yield, which was uncommonly high up to June. The increase in the output, from 188,000 tons in September to 203,200 tons in October, is accounted for chiefly by the pumping and compressor work. The number of wells in operation rose from 707 in September to 1000 in October, 1058 in November, and 1150 in December. Drilling operations also increased, the total accomplished for November being 2632 lin. ft. of bore-holes and for the first 10 days of December 1232 ft., the estimated total for the month being 3640 ft. Production totaled 220,560 tons in November and 245,000 tons in December.

Shipments of crude oil from Baku amounted to 284,000 tons in October, a decrease of 40,000 tons against the previous month. The available reserves of crude oil declined from 2,214,800 tons on Oct. 1 to 2,040,000 on Nov. 1.

The number of men employed in the oil fields was scarcely 25 per cent. of the 1914 total, which was about 43,000. In the summer of 1921 arrangements were made with 5200 Kuban Cossacks, who had fought under Gen. Wrangel and were then in concentration camps at Lemnos, to work for six months in Baku as a condition of their repatriation. These men worked well and it was chiefly due to them that the administration managed to operate an increased number of wells. Half of these Cossacks left in December, at the end of their contract term. Nevertheless, a steady influx of men from Ardabil and Zangezour, whence the best Baku labor was always recruited, more than made up this loss, the total number of men showing an increase of 1900 for the last quarter.

The labor situation is a source of considerable anxiety to the administration. There is an acute shortage of clothing and shoes, as well as technical equipment, such as compressor piping and pumping tackle and ropes. The Bolshevist official publication, *Economic Life*, states in its issue of Dec. 25 that at that time the men had not as yet received their October wages, while the rate of earnings due was increasing apace.

Production of crude petroleum in the Baku oil fields is reported to have increased 15 per cent., and is at present equal to about 50 per cent. of the output in 1916. Working is proceeding on the Nobel properties and on those of the Société Caspienne, Mantachev, Shibaiev, Ter-Akopov, and one or two other undertakings at Sabonntchy. Operations are also being carried on at Bibi-Eibat, Sourakhany, and Kichly. The plant is in a very bad condition, two-thirds of the machinery requiring renewal, and if this is not effected within the next eight months production may be expected to fall by 50 per cent. The working of the Baku-Batum pipeline is very irregular, and occasionally stops for several weeks, owing to insurrections in Georgia. There is a shortage of skilled labor and trained engineers, who are paid very high salaries. Only six undertakings are reported to have been leased to private interests.

Based on reports from the Russian official press, the following table

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shows the results of exploitation in the Grozny district for 1921 compared with the previous year:

	1921.	1920.
Total production, long tons	1,319,700	840,000
High-grade oil (free of paraffin), long tons	470,000	305,000
Consumed at fields, long tons	150,800	67,300
Percentage of gross yield consumed at fields	11.4	9.22
Drilling accomplished, feet	7,305	4,221

The number of wells under exploitation was 155 in December (as against 87 in January, 1921) and rose to 164 in January, 1922. The average drilling for the last quarter amounted to 560 ft. per month, but the monthly total for December was 933 ft. and for January, 1922, 1021 ft. The number of men employed in November was 7600.

Although oil production has increased, shipments of oil have declined. The monthly shipments from August to November (later figures are not available) were: August, 7929 cars of 10-ton capacity; September, 5813 cars; October, 5563 cars; November, 4786 cars.

The total production of oil in the Emba district for 1921 amounted to 70,200 tons, as against 31,500 tons in 1920. The number of producing wells increased from 7 in January to 33 in December. Consumption at the mines amounted to 4000 tons in 1921, or 10.7 per cent. of the gross yield, as against 6700 tons in 1920, or 22½ per cent. of the gross yield. The normal pre-war consumption at the mines for this district was 7 per cent.

Drilling up to August amounted to 650 ft. as against 210 ft. for the year 1920. Drilling has been discontinued in the Emba district since August, 1921.

Spain.—According to Consul B. Harvey Carroll, Cadiz, a number of locations have been made recently in the Cadiz consular district on supposedly petroliferous lands, the total increase for last year amounting to a little over 10,000 hectares. Nearly all of the increase is covered by claims owned by the newly organized company, Sociedad Petrolifera Hispanica, which is said to be capitalized at 20,000 pesetas. Mexican and French engineers recently visited the petroleum zones and are reported to have been highly pleased with the surface indications.

In November, 1921, a royal published order authorized the importation, free of duty, of drilling machinery which must be re-exported from Cadiz at the conclusion of the drilling of test wells. The officials are very hopeful of important developments, provided foreign companies are sufficiently interested to explore the fields thoroughly.

Africa

Algeria.—Consul Edward A. Dow, of Algiers, reports the discovery of petroleum by a French company at Medjeela. The well flows about 20 bbl. a day. Many other wells have been worked near-by for years, but

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with indifferent success. The English have ceased operating their concession after several years of exploration. Petroleum production of Algeria in 1921 was 500 metric tons (3205 bbl.) according to the Algerian Director of Public Works, Railways and Mines. The output in 1920 was 609 tons (3916 bbl.).

Egypt.—The oil probabilities of Egypt are well discussed in a paper before the Institution of Petroleum Technologists, London, by the Director of the Egyptian Geological Survey.

During 1921 the output of crude petroleum in Egypt was 182,668 metric tons as compared with 147,950 metric tons in 1920.

The production of the past 11 years is as follows:

	Metric Tons.[1]		Metric Tons.[1]
1911	2,793	1917	136,845
1912	27,962	1918	281,885
1913	12,786	1919	224,300
1914	99,680	1920	147,950
1915	30,054	1921	182,668
1916	57,743		

[1] 1 metric ton = 7.5 U. S. barrels.

During the year 1921 there was considerable increase in prospecting activity and eight new bores were in process of drilling on hitherto undrilled territory.

The Egyptian Government has maintained its geological investigations on both sides of the Gulf of Suez and has been engaged in drilling operations. The small Government refinery, intended in the first instance to treat royalty oil, is nearly completed and is expected to be in operation towards the close of 1922.

The Dutch Shell Co. produces oil from the Hurgadah, located in Egyptian territory, on the Black Sea. Thence the oil goes to their refinery at Suez. The production is estimated at 500,000 bbl. a year. Most of the product is shipped to Spain from Alexandria. Some oil is imported from the Persian Gulf.

Madagascar.—The following is a translation of an excerpt from a report by the Mine Service of Madagascar, published in the *Bulletin Economique*, Tananarive:

> The exploration work for petroleum that was undertaken by two English companies at Morobosaly and Morafenobe was not continued during 1920. A number of mining claims have been made by foreign prospectors. The colony, in order to reserve for French capital a part of the land reputed to contain petroleum, has taken in its name nearly 1,800,000 hectares (4,446,000 acres) in the regions of Morafenobe and Nossi-Be and the claims will be put in court for adjudication within a short time.

Union of South Africa.—The Wakkerstroom and Eemelo oil shales in the Transvaal, which were described in MINERAL INDUSTRY for 1920, continue to attract much attention, and serious efforts are being made for their development.

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ASIA

India.—Oil has been found to a small extent in the Punjab and Baluchistan, but the main petroleum-producing region of India is in the east; *i.e.*, Burma and Assam. By far the greatest supply of oil in India comes from Burma, of which the Yenangyoung oil field gives the largest production.

The total annual production in India for the period 1908–1921 has been as follows:

Year.	Burma, Tons.	Assam, Tons.	Punjab, Tons.	Total, Tons.
1908	693,611	12,972	2	706,585
1909	921,586	13,123	3	934,712
1910	846,031	13,283	4	859,318
1911	888,902	14,261	6	903,169
1912	981,341	14,900	4	859,318
1913	1,089,062	18,754	5	1,107,821
1914	1,018,612	18,754	5	1,037,371
1915	1,129,168	18,200	1,005	1,148,373
1916	1,167,076	20,948	735	1,188,759
1917	1,091,181	37,379	2,478	1,131,038
1918	1,099,338	43,999	3,003	1,146,340
1919	1,174,995	47,155	457	1,222,607
1920	1,108,429	53,433	206	1,162,068
1921	.....	.....	.....	1,300,000*

* Estimated.

A detailed discussion of the oil fields of Burma and India is published in *The Petroleum Times* of Apr. 29, 1922.

Japan.—The old oil fields of Japan are declining. In 1920 2,139,777 bbl. was produced. Many conferences between different branches of Japanese trade and the Government's geologists and others were held in 1921 to promote the discovery and better utilization of petroleum. Among the latter objects is the cracking of the heavy oil to gasoline.

OCEANIA

Australia.—Prof. David, of Sydney University, who is a recognized authority on Australian geology, says that there are only three regions in Australia where the prospects for occurrence of rock oil are good. These regions are New Guinea; the Kimberley region of Western Australia; and the eastern portion of the Queensland artesian belt between Roma and Blackall.

Small but genuine seepages are, he says, found over a wide area in the Kimberley district, and he believes that, though it may be several years before good oil pools are located, they eventually will be discovered. At Roma, Queensland, natural gas was struck several years ago at 3700 ft. It is mostly marsh gas, but 10 to 12 per cent. is petrol-oil gas and has been condensed into pure petrol oil. The great difficulty with this well has been artesian water under great pressure in the stratas above and below the gas. The result is that the flow of water entirely cuts off the supply of gas. Another well is being put down near Roma.

In New Guinea, according to Prof. David, are both oil springs and gas

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springs, but the strata needed to form an impervious lid to prevent the oil in the subterranean pools from being lost through evaporation have, so far as geological examination has gone, proved too shattered to prevent the loss of oil. The geologists are now seeking more settled country to the east of the present bores.

The Commonwealth Minister for Home and Territories has approved a new ordinance governing oil prospecting in the Northern Territory of Australia. This territory is a federally controlled area, subject to the Federal administration and not to the State governments. It is practically uninhabited (about 4000 whites in over 500,000 sq. mi.). Travelers have reported surface indications of oil along the northern rivers. Under the new ordinance, licenses for five years will be granted at an annual fee of £10, with the condition that at least four white men must be employed on prospecting work in each area for six months of the year. It is reported that several prospecting parties are being organized.

Borneo.—In a lecture before the Institution of Petroleum Technologists, London, Mr. James Kewley described the conditions of occurrence and the characteristics of petroleum in Borneo. Production has reached 4000 tons a day of oil which has become noted for its high percentage of oils of the aromatic series, which make it valuable as a source of toluol.

Dutch East Indies.—Production reached 18,000,000 bbl. in 1921, a gain from 17,529,210 bbl. in 1920. The condition of the much-discussed Djambi field in Sumatra is well described by Arthur H. Redfield.[1]

The following table, given in the Jan. 2, 1922, issue of *Commerce Reports*, shows the production of mineral oil in the Dutch East Indies, by districts, during the past four years:

PRODUCTION OF OIL IN THE DUTCH EAST INDIES

Districts	Metric Tons.			
	1917.	1918.	1919.	1920.
North Sumatra	175,839	194,213	176,458	194,440
North Palembang	82,917	121,561	148,295	138,315
South Palembang	222,321	204,215	197,003	203,727
Total of Sumatra	481,277	519,989	521,756	536,482
Semarang Residency	16,790	12,466	7,200	33,818
Rembang Residency	180,827	172,759	194,329	259,371
Soerabaya Residency	55,104	55,952	56,986	59,260
Madura	94	35	140	25
Total of Java and Madura	252,815	241,212	258,655	352,474
Dutch North Borneo	251,939	333,693	602,031	711,108
North Koetei	22	140	64	.....
South Koetei	617,301	665,733	602,278	744,119
Total Dutch Borneo	869,262	999,426	1,372,140	1,455,227
Island of Ceram	2,256	3,574	7,311	21,137
Grand total for Dutch East Indies	1,605,610	1,764,201	2,159,862	2,365,320

NOTE.—1 metric ton = 6.29 U. S. bbl.

[1] *Eng. Min. Jour.*, Dec. 10, 1921.

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Petroleum Refining

On Jan. 1, 1922, there were 303 refineries operating in the United States with a total indicated daily capacity of 1,736,725 bbl., according to the compilation of H. J. Lowe, petroleum economist of the Bureau of Mines. These figures are to be compared with 328 refineries having a daily capacity indicated at 1,714,395 bbl. on Jan. 1, 1921. Operations at the latter date were on the basis of 84 per cent. of capacity and on Jan. 1, 1922, at 80 per cent.

During 1921 the refineries of the United States distilled 75,325,670 bbl. of Mexican crude oil; 2,745,015 bbl. of Mexican tops and 160,557 bbl. of Mexican crude naphtha. The run of Mexican crude exceeded that of 1920 by 19 per cent.

Gasoline

The following figures on the production and consumption of gasoline are of interest in showing its increasing importance:

THE INCOME AND OUTGO OF GASOLINE IN GALLONS

Income.	1918.	1919.	1920.	1921.
Stocks, Jan. 1	412,256,833	297,326,983	446,793,431	462,381,837
Production	3,570,312,963	3,957,857,097	4,882,546,649	5,153,549,318
Imports	12,899,350	8,520,169	46,066,110	37,816,004
Total	3,995,469,146	4,263,704,249	5,375,406,190	5,653,747,159
Outgo.				
Exports	556,422,334	365,883,011	635,247,487	524,279,031
Shipments to insular possessions	12,209,957	16,217,081	21,348,911	27,368,017
Domestic consumption	3,129,509,872	3,434,810,726	4,256,427,955	4,516,012,979
Stocks, Dec. 31	297,326,983	446,793,431	462,381,837	586,087,132
Total	3,995,469,146	4,263,704,249	5,375,406,190	5,653,747,159

The monthly production during this period as well as the stocks on hand at the end of the month are shown graphically in Fig. 1. Maximum

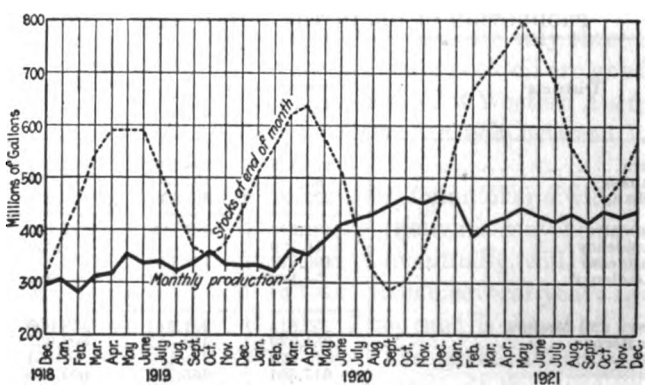

Fig. 1.—Gasoline production and stocks.

rate of production was reached in October and December of 1920, although the total output for the year was at its maximum in 1921.

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Other petroleum products produced by American refineries in 1921 are presented in the table. The column headed "Miscellaneous" includes the following materials and quantities:

	Gallons.		Gallons.
Binder	18,527,055	Pitch	129,800
Flux	27,353,495	Residue	5,786
Medicinal oils	761,008	Slops	757,125
Paint products	266,220	Tailings	180,624
Petrolatum	7,250,636	Tar	3,374,166
Road oil	125,820,652	Tops	122,267,027
Roofers' wax	66,166	Unfinished	227,446,245
Sludge products	34,672,612	Wash-out	25,280
Acid oil	2,271,513	Wax tailings	3,687,074
Distillates	627,570,679	Total	1,202,433,163

Stocks of gasoline held in storage by American refineries reached 800,495,787 gal. in May, 1921. These are said to be the largest gasoline stocks ever recorded in this country. On Dec. 31, 1921, gasoline in storage had decreased to 586,087,132 gal., which is but little more than 10 per cent. of the ouput for the year. Storage at the end of 1920 was 123,705,000 gal. less than that reported for the last of 1921. The domestic consumption of gasoline for 1921, however, exceeded 1920 by 260,000,000 gal. and 1919 by 1,081,000,000 gal.

The exports and shipments for 1921 amounted to a daily average of 1,511,000 gal. This figure is 283,000 gal. less than the daily average for 1920, but 463,000 gal. in excess of the corresponding figure reported for 1919.

The consumption of gasoline increased 9 per cent. in 1921 over 1920.

Fuel Oil Consumption

The United States Navy in 1921 consumed approximately 7,200,000 bbl. of fuel oil, compared with 6,714,000 bbl. in 1920, according to figures furnished the American Petroleum Institute by the Navy Department.

According to information furnished by the United States Shipping Board, Shipping Board vessels in 1921 consumed 16,388,912 bbl. of fuel oil. Of this quantity 13,149,322 bbl. was Mexican fuel oil and 3,750,590 bbl. was domestic fuel oil. The consumption of these vessels at United States ports and at United States insular possessions was 10,590,370 bbl. of Mexican fuel oil and 3,644,064 bbl. of domestic fuel oil, a total of 14,234,434 bbl. Consumption at foreign ports was 2,558,952 bbl. of Mexican fuel oil and 106,526 bbl. of domestic fuel oil, a total of 2,665,478 bbl.

The records of the Shipping Board show a total consumption of fuel oil by Shipping Board vessels in 1920 of 8,657,673 bbl.

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Methods of Testing Petroleum Products

The standard methods of petroleum tests have been ably codified in the new "Handbook of the Petroleum Industry" by Dr. T. G. Delbridge, chief chemist of the Atlantic Refining Co. The progress in testing methods since that publication is given below:

On flash-point determinations, the methods by Tag closed cup and by Pensky-Martens apparatus are proving to be entirely satisfactory and will not need any revision. The Cleveland open-cup method has been criticized on account of the large flame necessary in the case of oils having a high flash point, this probably being due to the plate which retards heat transfer from the flame to the oil. There is no definite decision as to the ultimate change. For the present, the 1921 method will be followed and the flame used will necessarily be large enough to meet the conditions.

On distillation of gasoline, etc., there has been considerable discussion, first as to the use of cotton on the bulb, and second as to the shield. While definite final action has not been taken, it is considered that cotton will be eliminated from the bulb and that the specifications for the shield will be simplified so that any satisfactory shield may be used. The shield specifications will probably be drawn up to give definite limits for inside and outside diameters and for height, leaving the details of construction to individual preference.

The method for melting point of paraffin wax appears to be entirely satisfactory, with the exception that there has been some effort to have the Saybolt method adopted. Since the results obtained by the Saybolt method will depend largely on atmospheric temperature, they are not so definite and duplicable as those obtained by the A. S. T. M. method. For this reason the Saybolt method will not become an A. S. T. M. standard, although it will continue to be used in many laboratories, since under normal conditions it gives the same results as the A. S. T. M. method.

The subject of viscosity has been very carefully studied during the past year with particular reference to establishing a definite viscosity standard for lubricating oils and a definite means whereby the users of viscosimeters may have the Bureau of Standards report first Saybolt viscosity on samples submitted and second a definite mathematical equation for any Saybolt viscosimeter which may be submitted to the Bureau of Standards. Such an equation will show two things, first the relation between kinematic viscosity on any sample and the Saybolt outflow time on the same sample as determined by the instrument under test; second, the difference between the Saybolt instrument under test and a normal Saybolt instrument.

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OUTPUT BY MONTHS OF THE PETROLEUM REFINERIES IN THE UNITED STATES FOR 1921

	Run to the Stills		Gasoline. (Gal.)	Kerosene. (Gal.)	Gas and Fuel. (Gal.)	Lubricating. (Gal.)	Wax. (Lb.)	Coke. (Tons)	Asphalt. (Tons)	Miscellaneous (Gal.)	Losses. (Gal.)
	Crude Oil. (Bbl.)	Other Oils. (Bbl.)									
January	39,637,382	4,206,576	460,432,439	205,374,611	836,684,040	85,908,641	45,659,668	57,961	80,672	145,846,215	1,664,203
February	34,588,096	2,942,666	388,188,252	163,081,918	732,542,415	72,432,219	40,384,408	55,029	74,508	120,075,769	1,440,377
March	35,509,115	2,788,737	419,795,390	169,247,894	758,334,681	73,003,304	37,719,575	45,475	84,774	85,849,195	1,575,538
April	37,594,220	2,363,193	426,215,200	156,156,565	813,144,202	76,456,958	39,200,197	51,386	86,120	96,017,271	1,699,652
May	36,990,478	2,823,694	448,567,873	145,225,023	817,367,590	70,000,194	31,441,634	49,891	102,327	84,823,852	1,573,090
June	36,940,821	2,740,131	430,344,393	141,637,081	826,355,262	63,088,609	29,860,281	43,567	109,565	100,049,466	1,546,123
July	36,040,797	2,649,364	419,641,815	138,724,132	807,428,397	65,893,228	25,070,736	43,496	111,523	83,999,461	1,610,271
August	36,044,910	2,705,120	431,577,195	143,652,290	784,450,485	66 473,473	28,498,408	42,602	112,943	92,463,702	1,596,083
September	35,613,933	2,999,042	416,913,000	154,017,299	788,408,124	69,053,367	33,054,167	44,863	107,420	83,050,575	1,638,549
October	37,968,496	3,727,357	440,955,518	182,453,598	833,775,254	75,971,377	38,264,778	52,368	153,118	93,656,968	1,796,781
November	37,211,534	2,956,469	431,886,845	175,240,466	799,256,607	77,005,042	41,574,253	54,338	103,834	86,524,716	1,722,052
December	39,222,875	3,590,216	439,031,398	170,315,279	865,769,078	82,572,662	43,159,109	63,489	87,732	130,075,973	1,694,798
Total	443,362,657	36,492,565	5,153,549,318	1,945,126,156	9,663,816,135	877,8 9,074	433,887,214	604,465	1,214,536	1,202,433,163	19,557,517

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The method proposed for the determination of total sulphur in petroleum products, which method appeared as an appendix to the Sulphur Sub-Committee's report, has been modified slightly in details and will probably be adopted.

Considerable co-operative work has been done on methods involving the centrifuge both for precipitation number and for water and sediment. The most important results will be standardization of equipment by the manufacturers. There has been some objection to the diluent used for the determination of precipitation number, the California refiners feeling that the method was not fair to the California lubricating oils. No definite decision will be reached in 1922.

The methods for determining cloud and pour point will probably be modified slightly, but it is too soon to predict in just what manner.

Additional work has had to do with the methods of determining gumming properties of gasoline, the proper characteristics in methods of test for gas oils, for gas-absorbent oils, for turbine oils, and for motor oils. None of this work is far enough advanced to be made public.

The subject of an emulsification test is still under discussion and the R. E. test has been modified chiefly as to the method of reporting results, and appears to be gaining in favor not only in the petroleum industry, but among consumers of petroleum products.

The work on testing methods is being assisted greatly by the wholehearted co-operation of the American Petroleum Institute through Dr. Van H. Manning, Director of Research. The marked achievement has been the adoption by the American Petroleum Institute of the A. P. I. scale for gravity, which scale is based on the modulus 141.5. This scale will then replace in the petroleum industry the present Beaumé scale based on a modulus of 140. The Bureau of Standards has very graciously agreed to this arrangement.

Some progress has been made leading to the adoption of uniform methods for correcting volume for temperature on petroleum products. It is probable that the results of this work will be published sometime before August, 1922, though at that time it probably would be published as a contribution from the laboratories of the Atlantic Refining Co.

Oil Shales

United States.—While the low price of petroleum has checked oil-shale development, there has been great progress in the acquisition of oil-shale lands by large corporations, and very little shale land is now for sale where the title is good. Even foreign corporations have shown considerable interest in the subject. The finishing of assessment work and payment of patenting fees has led to final patenting of some shale lands

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during the year. Successful tests were made near DeBeque, Colo., of the Brown process by the Index Oil Co. The Galloupe process is being developed in Montana. Mr. Galloupe is the first shale man in this country to burn the coke in the spent shale for heating the retort. The Johns process is to receive trial near Knoxville, Tenn., on the rich shales associated with cannel coal. Leasing and other development work with the Day retort is proceeding in California.

In Canada the well-known Athabasca tar sands are being exploited for the first time, following the thorough investigations and surveys of Mr. Ells for the Canadian Department of Mines. A few carloads of crude shale oil were sold for street use and for flotation work from the DeBeque, Colo., region in 1921. Most promising of all has been the careful and persistent work carried on by Mr. R. M. Catlin, at Elko, Nev., where, besides the necessary retorts, a redistillation plant and a wax plant have been installed. The large percentage of wax produced has an exceptionally high melting point and good color. The decolorizing material is obtained from the shale deposit.

Scotland.—The oil-shale industry of Scotland has suffered from the low prices following the reaction of the post-war period, but the work is proceeding.

Chile.—Discovery of a large area of petroleum-bearing schist or shale has been made at Chucumata, a small local port some 24 miles south of Iquique, according to a recent newspaper article, announces Consul Homer Brett. Samples weighing about 300 lb. were analyzed by the Nitrate Industrial School in Iquique and it was found that the petroleum content was large. Twenty-one mining claims of 50 hectares each have been filed, and a company called the Compania Nacional Petrolifera Luz de Chile has been organized, of which Don Miguel L. Marquez, of Iquique, is President and General Manager. The degree of importance attaching to the discovery can not be determined until borings have been made.

Palestine.—Attention has been called to oil shales and oil sands occurring near the shores of the Dead Sea. They were developed to some extent during the war. In the Yarmonk Valley, in northern Palestine, large deposits of oil-impregnated limestone are known to occur.

Australia.—The oil-shale industry has had many severe trials of management and questionable technical methods. Lately improved retorts are expected to produce 15,000 gal. per day.

Mr. Douglas A. Fell, who is the son of Mr. J. W. Fell, the developer of the Australian shale industry, has well reviewed the oil-shale industry in the London *Petroleum Times* of Mar. 25, 1922. Mr. Fell is now associated with the study of shales in the Bureau of Mines.

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Russia.—A commission of Russian mining engineers visited the United States in 1913. They reported extensive high-grade oil-shale deposits in Esthonia, between Narva and Rakvere. The engineers received sufficient encouragement on their inspection of the prospective oil-shale developments in the United States to cause them to recommend development of the Esthonian deposits. This was commenced just in time to add a valuable fuel during the war. The shale was chiefly burned as fuel. Lately the distillation of oil has begun and a Government subsidy is promised for the enterprise.

Upon the termination of the German occupation of Esthonia the temporary government organized a special board of oil-shale mining, and in addition to the Kochtel mine, where a plant for distillation was erected, mining was started at Vanamois (open quarries) and Kuckers (pit).

The layers of the Esthonian bituminous shale extend across the whole of Esthonia from Baltic Port to Narva. The deposits of oil shale are estimated at 1,500,000,000 tons. The Government mines are situated at the extreme points of the shale area, the land between these points being left for private concessions. It is reported that the Government is willing to sell the Vanamois mine to the highest bidder.

All present private concessions were granted during 1921, but none of them have as yet begun mining operations. All the actual mining is still carried on by the Government. The deposits lie near the surface (2 to 5 meters) and the shale is taken out by quarrying. Only in the southern sections will underground mining operations be necessary.

According to the analysis of Prof. Helmerson, Esthonian oil shale contains: (*a*) Volatile substances, 70.06 per cent.; (*b*) coke, 11.08 per cent.; (*c*) ashes, 18.86 per cent.

The total output of Esthonian oil shale was 588,007 poods (9484 long tons) in 1919, 2,815,831 poods (45,417 long tons) in 1920, and 5,775,751 poods (93,157 long tons) in 1921. The mining operations at Kuckers and Vanamois are still in the preliminary stages.

A complete battery of retorts, to have a total capacity of 200 metric tons of oil shale in 24 hr., will be erected at Kochtel in 1922.

The Government is very optimistic as to the future for oil from Esthonian shale and is anxious to interest foreign capitalists therein.

Natural Gas

United States.—Gradually advancing prices have proved a successful expedient for keeping up the supply of natural gas, and even to effect a slight increase in the amount produced, as well as in the total value. Thus in 1919 the United States produced 798,859,412 thousand cubic feet, valued at $160,888,312; while in 1920 production rose to 860,540,000

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thousand cubic feet. The U. S. Geological Survey calls attention to the fact that of the amount reported produced in 1920, 62,330,000 thousand cubic feet was wasted, most of it at the wells; the figure does not include gas wasted in transmission and utilization. The value of the total consumption in 1920 increased 23 per cent. over 1919.

The table given below shows the amount of gas produced in each state and the amount which each state consumed. The difference between these two quantities is ever increasing with the more ambitious projects for piping gas to distant points of consumption. There was little change in the relative importance of the producing states, though the discoveries of gas wells were marked in Arkansas and Montana.

NATURAL GAS PRODUCED AND CONSUMED IN THE UNITED STATES IN 1920 (a)

State	Production.		Consumption.			
	Per Cent. of Total.	Volume (M. Cu. Ft.).	Per Cent. of Total	Volume (M. Cu. Ft.)	Average Price, Cents per M. Cubic Feet.	Value.
West Virginia	28.4	244,745,000	12.6	100,289,000	18.0	$18,015,000
Oklahoma	19.3	166,265,000	15.9	126,689,000	14.8	18,699,000
Pennsylvania	14.9	128,175,000	20.2	161,397,000	32.1	51,863,000
California	8.5	73,263,000	8.3	66,041,000	19.0	12,529,000
Ohio	8.4	71,854,000	17.1	136,872,000	36.8	50,374,000
Louisiana	7.4	63,545,000	5.8	46,219,000	07.1	3,283,000
Texas	5.1	44,160,000	6.2	49,467,000	19.0	9,398,000
Kansas	3.1	26,891,000	4.1	33,140,000	26.0	8,603,000
Wyoming	1.5	12,956,000	1.3	10,312,000	07.8	805,000
Arkansas	1.1	9,614,000	2.4	19,050,000	21.1	4,021,900
New York	1.0	8,522,000	2.4	19,127,000	45.6	8,721,000
Kentucky	0.6	4,677,000	1.9	15,297,000	31.8	4,865,000
Illinois	0.4	3,150,000	0.4	3,013,000	15.8	477,000
Indiana	0.2	1,853,000	0.5	4,435,000	42.7	1,893,000
Montana	.....	820,000	.....	818,000	10.6	88,000
South Dakota	.....	20,000	.....	20,000	60.0	12,000
Tennessee	.....	15,000	.....	15,000	20.0	3,000
Colorado	.....	8,500	.....	8,500	12.9	1,100
Missouri	.....	3,800	.....	5,429,000	67.9	3,684,000
North Dakota	.....	1,100	.....	1,100	27.3	300
Iowa	.....	800	.....	800	37.5	300
Michigan	.....	400	.....	400	75.0	300
Oregon	.....	200	.....	200	50.0	100
Maryland	.....	200	.....	569,000	56.9	324,000
Total	100.0	860,540,000	100.0	798,210,000	24.8	197,660,000
1919		798,860,000	.....	739,916,000	21.7	160,888,000

(a) U. S. Geol. Surv.

Canada.—The production of natural gas in Canada in 1921 amounted to 15,043,944 thousand cubic feet, valued at $4,902,000, which was a decrease in quantity of 1,800,000 thousand cubic feet, but an increase in value of nearly $700,000.

Most of the increase in the value of the natural gas was credited to Ontario, which produced 9,256,157 thousand cubic feet, valued at

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$3,658,200, as compared with 10,529,374 thousand cubic feet in the preceding year, valued at $2,920,731.

The production of natural gas by provinces for the past two years is shown in the following table:

CANADIAN NATURAL-GAS PRODUCTION (a)

	1920.		1921.	
	M. Cu. Ft.	Value.	M. Cu. Ft.	Value.
New Brunswick	682,502	$ 130,506	708,743	$ 139,375
Ontario	10,529,374	2,920,731	9,256,157	3,658,201
Alberta	5,633,442	1,181,345	5,079,044	1,104,444
Manitoba	200	60	.....	.....
Total	16,845,518	4,232,642	15,043,944	4,902,020

(a) Dominion Bur. of Statistics.

Natural-gas Gasoline

The industry of obtaining gasoline from natural gas by compression and by absorption progresses rapidly, and instead of depleting the gas supply rather adds to the total by making available casing-head gas from many oil wells where the gas would otherwise not be worth collecting at all.

Mr. H. C. Cooper[1] has recently published a very comprehensive statement of the methods of obtaining gasoline from natural gas, with special reference to the needs of the construction engineer.

The output of natural-gas gasoline in 1921 increased 23 per cent. over that in 1920, but the market was rather unstable because of the depression in the petroleum industry, according to a preliminary statement by E. G. Sievers, of the U. S. Geological Survey. Seventy-five per cent. of the output was recovered at compression plants and the remainder at absorption plants. The average daily production was 1,297,000 gal., as compared with 1,054,093 gal. in 1920.

A decrease in the value of natural-gas gasoline was naturally produced. The total value in 1921 was about $6,000,000 less than in 1920. The prices received by the producers declined to 8 cts. a gal., and the average price as computed from the total output in 1921 was 5 cts. less than in 1920. Although the output was greater, 5 per cent. less gas was treated, so that the plants showed increased efficiency in 1921. The average yield of gasoline per thousand cubic feet of gas was 0.2 gal. greater in 1921 than in 1920.

[1] Handbook of the Petroleum Industry.

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UNBLENDED NATURAL-GAS GASOLINE PRODUCED IN THE UNITED STATES IN 1921

State.	Number of Plants.	Gasoline Produced.			Gas Used.	
		Quantity, Gallons.	Value.	Average Price per Gallon, Cents.	Estimated Volume, M. Cu. Ft.	Average Yield of Gasoline per M. Cu. Ft., Gallons.
Oklahoma	304	195,960,900	$22,509,300	11.0	78,229,800	2.5
Texas	68	89,749,600	11,668,400	13.0	26,751,700	3.4
California	77	59,483,300	10,627,600	18.0	63,916,900	0.9
West Virginia	204	53,557,600	9,772,100	18.0	135,631,300	0.4
Pennsylvania	305	19,989,600	3,303,200	17.0	46,482,800	0.4
Louisiana	28	15,420,300	1,830,200	12.0	46,451,700	0.3
Wyoming	7	14,557,600	1,599,600	11.0	4,559,600	3.2
Ohio	55	10,310,000	1,996,400	19.0	39,861,100	0.3
Illinois	89	6,358,500	919,200	14.0	2,992,800	2.1
Kentucky	9	4,241,900	835,000	20.0	16,520,100	0.3
Kansas	11	3,663,000	602,900	16.0	7,825,800	0.5
New York	4	366,200	54,000	15.0	203,000	1.8
Total, 1921	1,161	473,658,500	65,717,900	14.0	469,426,600	1.0
Total, 1920	1,154	384,743,922	71,788,122	18.7	496,430,952	0.78

Texas has become an active field for the natural-gas gasoline industry, with an output in 1921 that was 172 per cent. greater than in 1920, and occupied second place in the list of producing states. California also increased its production, but West Virginia, which was second in rank, showed a decrease and occupied fourth place.

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PHOSPHATE ROCK

By Wm. H. Waggaman

In 1921 conditions in the phosphate industry throughout the world were in many instances almost completely reversed from those existing in 1920. While the statistics are not entirely complete the figures as far as they are available show that the world's total output during the past year amounted to 4,736,126 tons as against 6,763,947 tons in 1920, or a decrease of nearly 25 per cent. This falling-off in production, however, was due almost entirely to the depression of the phosphate industry in the United States, where agricultural and fertilizer interests were severely affected by the drop in the price of farm products, and the rate of foreign exchange militated against the normal exports of phosphate rock.

The figures on foreign production in a number of instances are largely estimated, but the available statistics point strongly to the fact that for the first time in history the output from Algeria and Tunis surpassed the production of the United States. There is little question, however, that the conditions in 1921 were quite abnormal and in 1922 we will again assume our position as the foremost phosphate-producing nation in the world. It does seem likely, however, that certain European nations will draw more and more upon the African phosphates to meet their agricultural needs for phosphoric acid, since these deposits are not only much closer to certain points of heavy fertilizer consumption, but they are largely controlled and exploited by English and French capital. The grade of the African rock, however, is on the whole considerably lower than that of the Florida and Tennessee deposits, so that these latter phosphates will always be assured a foreign market. Moreover, the fact that the present consumption of phosphatic fertilizers in the United States is only a small percentage of what it will be in future years insures steady healthy growth for the American phosphate industry. Therefore, the temporary curtailment in our output in 1921 has not altered the relative importance of the various phosphate deposits of the world, which in the order of their commercial importance may be listed as follows:

The phosphates of the United States, including those of great value and extent in Florida, Tennessee, South Carolina, and the Western States, Utah, Idaho, Wyoming, and Montana, and deposits of less importance in

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Kentucky and Arkansas; the deposits of northern Africa, Algeria, Tunis, Egypt, and Morocco; the deposits of the Pacific and Indian oceans, including those of Ocean, Christmas, and Pleasant islands, and islands of the Marshall, Pellew, and Society groups; the phosphates of Russia, Belgium, France, England, and Spain; and a number of other smaller deposits in various other countries.

The world's output of phosphate rock based on material marketed for the past eight years is given in detail in Table I.

TABLE I.—PRODUCTION OF PHOSPHATE IN THE WORLD (a)
(In metric tons)

	1914.	1915.	1916.	1917.	1918.	1919.	1920.	1921.
Algeria	(e)355,140	(e)225,891	(e)389,211	(e)202,539	(e)198,539	276,040	502,614	(e)372,019
Angaur Island	(e)60,000	30,000	30,000	(c)	.....	30,000	30,000	(b)30,000
Australia	6,783	5,714	7,455	8,626	11,918	9,017	13,184	.....
Belgium	105,330	16,350	77,740	138,800	61,700	90,970	133,040	.....
Canada	866	197	184	135	127	24	*Nil.*	27
Christmas Island	95,234	24,119	44,209	89,889	53,370	.....	.....	(b)60,000
Dutch W. Indies, Aruba	(e)86,572	51,000	14,468	3,639	.....	9,890	64,969	.....
Curacao	(e)11,219	(e)32,915						
Egypt	71,945	82,998	125,008	115,732	31,147	29,365	114,813	122,024
France	270,000	145,000	25,000	(c)	.....	103,869	.....	.....
Japan	38,252	57,723	114,389	121,609	191,722	122,868	(b)120,000	(b)110,000
Nauru Island	72,000	92,000	97,000	98,000	83,000	(b)60,000	(b)100,000	(b)100,000
Makatea	72,925	71,724	39,285	32,259	(b)40,000	40,000	(b)40,000	(b)40,000
Norway	750	1,901	2,236	1,832	4,562	(b)1,162	*Nil.*	.....
Ocean Island	158,000	126,000	105,000	101,000	70,000	53,000	(b)200,000	(b)200,000
Russia	15,000	.....	56,452	.....	.....	.....	375	(b)9,800
Spain	8,312	9,080	14,111	28,148	43,303	25,035	42,896	.....
New Zealand	10,740	(b)10,000	7,600	5,050	5,000	4,064	(b)10,000	.....
Tunis	1,427,161	1,389,074	1,695,295	999,326	818,962	815,385	1,222,000	1,595,000
United States	2,752,971	1,873,625	2,177,292	2,652,776	2,530,861	2,308,562	4,170,056	2,097,256
Total	5,619,219	4,150,311	5,072,335	4,597,360	4,114,211	3,979,251	6,763,947	4,736,126

(a) Based on marketed output. (b) Estimated. (c) Statistics not available. (e) Exports.

UNITED STATES

Since the discovery of phosphate rock in South Carolina in 1868 up until the past year the United States was the foremost phosphate-producing nation in the world. Although we have mined and marketed over 40,000,000 tons of phosphate in the past 20 years and lost or wasted fully as much again owing to our methods of mining and separating the phosphate from its impurities, our known reserve supplies of this mineral are being constantly increased by new discoveries. The latest estimated amount of high-grade rock and its low-grade equivalent according to the U. S. Geological Survey is placed at fully 10,500,000,000 tons. Much of this reserve supply, however, is located in our Western States, so far removed from fertilizer centers that its extensive exploitation has not yet been commercially practicable. The actual production of phosphate

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rock in this country in 1921 according to the figures of the U. S. Geologica Survey was 2,426,174 long tons, but the marketed output was only 2,064,-025 tons. This was in sharp contrast to the output in 1920 when we marketed a total of 4,103,982 tons, the largest amount for any single year on record. This great decrease in the output in 1921 was due not only to the lack of buying power on the part of the American farmer, but also to the rate of exchange which prevented foreign powers from purchasing their normal quota. Prior to the war our marketed output was about equally divided between this country and Europe, but the bulk of our production is now consumed in the United States. In 1921 only 733,312 tons was exported as against 1,069,712 tons in 1920. The greater part of this rock was shipped to Germany, Spain, Holland and Belgium.

While most of the phosphate rock consumed in this country is manufactured into acid phosphate, there was up until the past year a considerable demand for raw phosphate rock to be applied directly to the soil. In addition to this there is a considerable tonnage used in the manufacture of elementary phosphorus, ferrophosphorus, in the production of baking powder, in manufacturing rust-proofing compounds, for water-softening purposes, and for relatively pure chemicals. Complete statistics are not available showing the total quantity consumed for these purposes in 1921, but it is estimated at approximately 200,000 tons.

The production and value of phosphates from the various fields in this country for the past five years are given in Table II, and the total production, imports, exports, and domestic consumption for the past ten years are given in Table III. In Tables IV and V the imports and exports of various fertilizer materials, including both raw materials and finished products, are given.

TABLE II.—PRODUCTION OF PHOSPHATE ROCK IN THE UNITED STATES (a)
(In tons of 2240 lb.)

Phosphate.	1918.		1919.		1920.		1921.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
Florida soft rock...	17,736	$212,832	8,715	$104,580	13,953	$190,551	4,419	$20,153
Florida hard rock..	42,840	310,590	101,300	962,350	400,249	4,526,191	175,774	1,806,671
Florida land pebble.	2,141,950	5,997,460	1,159,419	6,956,514	2,955,182	14,748,620	1,599,835	8,604,818
Total, Florida...	2,202,526	$6,520,882	1,269,434	$8,023,444	3,369,384	$19,464,362	1,780,028	$10,431,642
S. Car. land rock..	51,387	$231,242	54,851	$329,106	44,141	$367,209	*Nil.*	.....
S. Car. river rock..	.....	.....	.....	.....	.....	.....	*Nil.*	.....
Total, S. Carolina	51,387	$231,242	54,851	$329,106	44,141	$367,209	*Nil.*	.....
Tennessee.....	430,288	$2,581,727	473,985	$3,791,880	634,848	$4,943,995	277,706	1,812,556
Other states.....	11,342	56,710	17,420	139,360	55,609	304,006	6,291	25,872
Total, U. S.....	2,695,543	$9,390,562	1,815,690	$12,283,790	4,103,982	$25,079,572	2,064,025	$12,270,070

(a) Marketed output, U. S. Geol. Surv.

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TABLE III.—STATISTICS OF PHOSPHATES IN THE UNITED STATES
(In tons of 2240 lb.)

Year.	Production.	Imports.	Exports. (a)	Domestic Consumption.
1912	3,166,032	28,821	1,206,520	1,988,333
1913	3,062,975	26,408	1,366,508	1,724,525
1914	2,752,971	15,078	964,114	1,839,057
1915	1,873,625	5,359	253,421	1,625,435
1916	2,177,292	4,612	243,678	2,081,467
1917	2,610,743	*Nil.*	166,358	2,653,829
1918	2,695,543	*Nil.*	143,891	2,346,869
1919	1,815,690	*Nil.*	434,251	1,991,891
1920	3,975,001	*Nil.*	1,070,012	3,033,970
1921	2,426,174	*Nil.*	733,312	1,330,713

(a) Neglecting the insignificant exports of foreign products.

TABLE IV.—IMPORTS OF FERTILIZERS INTO THE UNITED STATES (a)
(In tons of 2240 lb.)

	1918.		1919.		1920.		1921.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Ammonium sulphate	2,993	$425,881	2,369	$314,266	1,994	$247,495	4,677	$260,390
Phosphates (crude)	*Nil.*	.....	.....	.....	*Nil.*	.....	*Nil.*	.....
Apatite	1	30	.....	.....	*Nil.*	.....	*Nil.*	.....
Basic slag	.....	.....	.....	.....	*Nil.*	.....	*Nil.*	.....
Bone dust	5,183	154,231	6,116	207,885	18,266	966,255	21,516	799,591
Guano	8,206	280,544	7,017	255,992	53,790	4,583,313	1,751	89,527
Kainit	*Nil.*	.....	51,274	291,482	374,732	8,268,031	69,076	1,453,854
Manure salts, tons	*Nil.*	.....	40,542	1,271,628	317,911	10,730,274	38,648	792,601
Potash (muriate)	379	102,109	20,716	1,783,917	121,602	12,703,858	71,109	4,777,726
Potash (sulphate)	90	15,329	1,263	188,590	15,184	2,343,431	11,124	719,183
Nitrate of soda	1,845,192	90,379,285	407,459	19,558,961	1,321,922	63,129,196	369,173	17,982,977
All other fertilisers	.....	4,018,013	72,620	4,294,056	140,727	6,717,277	75,519	2,596,770
Cyanamid	26,191	1,360,557	62,121	2,717,693	71,305	4,541,870	16,589	970,719

(a) Bureau of Foreign and Domestic Commerce.

TABLE V.—EXPORTS OF FERTILIZER MATERIALS
(In tons of 2240 lb.)

	1920.		1921.	
	Quantity.	Value.	Quantity.	Value.
Superphosphates	80,993	$2,949,629	4,296	$98,343
Sulphur or brimstone, crude	477,450	8,994,350	285,762	4,524,788
Phosphate rock, not acidulated:				
High-grade hard rock	344,896	4,496,457	182,594	2,637,541
Land pebble	693,355	5,593,814	544,425	4,627,875
All other	31,761	500,904	6,714	117,989
All other fertilizers	205,366	15,581,658	54,800	2,581,969
Ammonium sulphate	59,566	7,433,350	102,614	6,098,406

(a) Bureau of Foreign and Domestic Commerce.

Florida.—The production of phosphate in Florida during 1921 was about two-thirds as great as in 1920, 2,426,174 long tons being produced as against 3,975,001 tons the previous year. The actual amount marketed in 1921, however, was only 1,775,609 tons, or a little over half of the amount sold in 1920 (3,369,384 tons). While twenty-eight com-

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panies operated during the year, most of these were only running intermittently and in most cases the plants were closed down for the greater part of the year.

The output from the hard-rock region in 1921 amounted to only 175,774 tons as against 400,249 tons in 1920. The average price of the hard rock for the year was $10.28 as against $11.30 per ton in 1920. In recent years the hard-rock fields have yielded an appreciable tonnage of what is known as soft phosphate. This is a clay-like material, very high in alumina, which is used for direct application to the soil. In 1920, 13,533 tons of this material was marketed at an average price of $13.70 per ton. In 1921, however, the price of this material fell to $4.50 per ton and there was only 4419 tons mined and marketed.

In the land-pebble regions the falling-off in production in 1921 was very marked. Only 1,599,835 tons was marketed as against 2,955,182 tons in 1920. Of the total output 544,425 tons, or a little more than one-third, was exported. The average price of pebble phosphate in 1921 was $5.32 per ton, but a considerable amount was sold during the latter part of the year at a figure much below this price. The statistics of Florida phosphates, including production, shipments, domestic consignments, and exports, are given in Table VI.

TABLE VI.—STATISTICS OF FLORIDA PHOSPHATE
(In long tons)

Year.	Production.			Total Shipments.	Domestic Consignment.	Exports.
	Hard Rock.	Pebble.	Total.			
1913	510,811	2,043,403	2,554,214	2,554,214	1,130,764	1,363,450
1914	309,689	1,787,597	2,138,891	2,138,891	1,209,898	928,993
1915	42,962	1,368,282	1,411,244	1,411,244	1,158,052	253,192
1916	81,071	1,601,061	1,682,132	1,520,706	1,317,270	203,435
1917	93,339	2,016,462	2,109,801	2,096,670	1,963,524	133,146
1918	42,840	2,141,950	2,202,526	2,067,230	1,944,894	122,336
1919	101,300	1,159,419	1,250,719	1,339,962	977,560	362,402
1920	400,249	2,955,182	3,355,431	3,355,431	2,317,180	1,038,251
1921	175,774	1,599,835	1,775,609	2,507,047	1,780,028	727,019

Tennessee.—The phosphate industry of Tennessee was also very severely affected by the slump in the price of farm products. The production in 1921, including a small quantity mined in the Kentucky fields, amounted to 332,962 tons as against 634,848 tons in 1920. Of the total amount produced in 1921, however, only 277,706 tons was actually marketed, as compared with a marketed output of 634,848 tons in 1920.

The brown rock or Ordovician phosphate is the most actively exploited type in Tennessee and modern methods of mining and up-to-date equipment are enabling the operators to recover much material which was formerly wasted. The most important centers where brown-rock mining

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is now being conducted are at Colombia and Mt. Pleasant in Maury County, near Centerville in Hickman County, and southeast of Wales Station in Giles County. The rock ranges in grade from 55 to 78 per cent. bone phosphate of lime, the average being about 72 per cent. The marketed output of brown phosphate rock in 1921 was 252,543 tons, as against 556,177 tons in 1920. The average price of the brown phosphate was $6.60 per ton as against $7.96 per ton in 1920.

The blue or Devonian phosphate is being mined near Gordonsburg in Lewis County, and also in the Centerville region. The average grade of blue rock is also about 72 per cent. bone phosphate of lime. In 1921 only 25,163 tons of blue rock was sold as against 78,671 tons in 1920; the average price for the past year was $5.80 as against $6.59 in 1920.

The deposits of white phosphate occurring in Perry and Decatur counties, Tennessee, resemble somewhat the hard phosphate-rock deposits of Florida, but the white rock is so irregular in its occurrence and the deposits as a whole contain so much chert that it has not proved profitable to mine them in competition with the more regular deposits of brown and blue rock. No production of white phosphate has been reported for at least ten years.

South Carolina.—For the first time since their discovery in 1868 the mining of the nodular phosphates of South Carolina ceased entirely in 1921. While the output from these deposits has shown a steady decline since 1908, the complete cessation of mining operations came as a surprise, particularly in view of the fact that 44,141 tons was produced in 1920. Whether or not mining operations in South Carolina will again be started is an open question, but it seems likely that in view of the large amount of mining and washing equipment in these fields work will be continued when the present depression passes. The South Carolina deposits are far from exhausted, but it has been difficult for this rock to compete with the phosphate of Florida and Tennessee, owing to the fact that the mining costs in these latter fields are lower and the rock is of higher grade.

Utah, Idaho, Wyoming, and Montana.—The phosphate deposits of these Western States are by far the most extensive in the world, the latest estimate of the amount of high-grade rock in these regions showing a reserve supply close to six billion tons. This tonnage is continually being enhanced by fresh discoveries as the survey of the phosphate area is continued, an extension of this field having recently been traced into Canada. The rock, which is of Carboniferous age, occurs in beds of a few inches to 6 ft. or more in thickness, and has an average content of 70 per cent. bone phosphate of lime. While most of the phosphate occurs on Government land, provision has been made for the leasing of such land on the payment of royalty to the Government. The minimum royalty

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is 2 per cent. of the gross value of the output, and a rental of 25 cts. an acre will be charged for the first year, 50 cts. an acre for each year from the second through the fifth year, and $1 an acre annually thereafter. No leases will be given for more than 2560 acres. The high price of phosphate rock during 1919 and 1920 encouraged private enterprises to go ahead with the development of some of these deposits, and one of the outstanding features of the phosphate situation in 1920 was the great increase in the output of phosphate from the western fields. In 1921, however, conditions completely changed and only 4961 tons of rock was produced and but 6291 tons marketed as against a marketed output of 55,609 tons in 1920.

Four companies mined intermittently during the year and the average price of the phosphate marketed was $4.11 per ton f.o.b. mines, which was about the same as in 1920.

Kentucky and Arkansas.—Although a number of deposits of phosphate similar in appearance and grade to the brown rock of Tennessee have been discovered in Kentucky, they have so far proven of rather limited extent. The output from the Kentucky deposits is included in the figures for Tennessee.

The Arkansas deposits are much lower in grade than the phosphates of Kentucky and Tennessee, and while the beds are fairly extensive they have not been mined since 1915.

Phosphates in Foreign Countries

Africa

Next in importance to the phosphate deposits of the United States are those of northern Africa, and so extensively have operations been conducted in Tunis, Algeria, and Egypt that in 1921 the output of these countries combined surpassed that of the United States.

In addition to the developed deposits of these regions immense phosphate beds have been discovered in Morocco in the districts of El Boroudj and Oned-Zem, about 80 miles south-southeast of the port of Casa Blanca. The phosphates belong to the Tertiary period, and while at first reported to be of a grade rivaling that of the Florida deposits, the average phosphoric-acid content was later found to be considerably lower. The formation at El-Boroudj is said to be nearly 100 ft. thick, containing four strata of phosphate, and the formation at Oned-Zem is 65 ft. thick, with three strata of phosphate. Some of the phosphate strata attain a thickness of 26 ft. A great deal of development work will have to be done and a railroad built before the Moroccan phosphates appear on the market in any quantity. At present there exists only a single-track narrow-

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gauge railroad in this region, which cannot handle more than 200,000 tons annually. Latest advices from France state that 500 tons of phosphate per week are being shipped from the Oned-Zem district. It is estimated that the annual shipments will reach 500,000 tons in 1926.

While the developed phosphates of Africa are somewhat lower in grade than those of Florida, Tennessee, and our Western States, their close proximity to the European and Japanese markets has made them in recent years the chief source of phosphate fertilizer for certain European and Asiatic nations. High freight-charges have also probably aided the development of the African phosphates, since the haul to the European market is comparatively slight as compared with the distance between America and Europe.

While complete statistics are not yet available giving the production from the African deposits in 1921, provision was made for an output of 2,342,024 metric tons as against 1,869,000 tons in 1920.

Tunis.—In normal times Tunis has an annual production of phosphate rock second only to that of Florida, but during the latter years of the war the production fell off to less than half of the pre-war output. In 1921, however, provision was made for the production of 2,064,025 metric tons by the companies operating in Tunis and it seems likely that fully this amount was mined. The exports increased greatly, as shown in Table VII.

The main phosphate district of Tunis is in the vicinity of Gafsa, which is connected with the port of Sfax by a railroad 150 miles long. The phosphate occurs in gigantic lenses of considerable thickness and ranging in grade from 53 to 68 per cent. bone phosphate of lime. The mining is done by open cuts as well as by tunnels. The Société de Phosphate de Gafsa, which controls all the phosphate in the Gafsa region, is the largest single producer of phosphate in the world. Up to 1914 its annual output was constantly being increased. The other companies in Tunis are the Sociétés des Phosphates Tunisiens and Compagnie des Phosphates du Dyr.

Algeria.—The Algerian phosphate deposits are of the same general type as those of Tunis and of a similar grade, although they have not been developed to the same extent as the Tunisian fields. Their output based on the material marketed has been well over a quarter of a million tons annually for more than 15 years, with the exception of the years 1917 and 1918 when abnormal conditions prevailed. In 1921 provision was made to produce 625,000 tons of phosphate in Algeria as against an output of 502,931 tons in 1920. The amounts exported are shown in Table VII. Four important companies are engaged in mining Algerian phosphate, all of them being controlled by French capital.

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Egypt.[1]—Deposits of phosphate occurring as beds in sedimentary strata are widely distributed in Egypt. They are very similar in character to those of Algeria and Tunis and present a field of considerable economic importance. The land now let under mining lease forms a very small proportion of the total area known to contain phosphates, so that there is ample opportunity for prospecting enterprise.

The localities in which phosphate is at present being mined are: the Safaja district near the Red Sea coast, the Kosseir district near the Red Sea coast, and the Sebaia district on the east bank of the Nile.

The rock phosphate is either shipped raw in bulk or manufactured into a finished fertilizer, of which two kinds are at present made in Egypt, namely, "Ephos Basic Phosphate" and "Tetraphosphate;" these are exported in bags.

The quality of the rock phosphate varies considerably and may be roughly divided into three grades.

Tricalcic Phosphate, Per Cent.	Iron and Alumina, Per Cent.
60.0	3.00
64.0	2.75
70.0	1.50

The phosphate produced in the Nile Valley is the lowest grade and is shipped from the port of Alexandria. The Red Sea districts produce the better qualities, which are despatched from the ports of Safaja and Kosseir. Port Safaja is a deep-water anchorage and has an installation for mechanical loading.

The Egyptian phosphate deposits are operated and controlled by English and Italian capital, but the bulk of the phosphate exported goes to Japan, Italy, Australia and New Zealand. The production in 1921 amounted to 122,024 metric tons as against 114,813 tons in 1920. Exports are given in Table VII.

TABLE VII.—SHIPMENTS OF PHOSPHATE ROCK FROM ALGERIA, TUNIS AND EGYPT
(In metric tons)

Year.	Algeria.	Tunis.	Egypt.	Year.	Algeria.	Tunis.	Egypt.
1900	277,896	171,288	.....	1911	332,897	1,446,633	12,013
1901	278,185	178,019	.....	1912	388,515	1,923,000(b)	70,918
1902	265,964	266,553	.....	1913(a)	438,601	1,984,880	64,183
1903	301,112	360,621	.....	1914(a)	355,140	1,427,161	76,571
1904	344,969	457,133	.....	1915	225,891	1,087,816	33,245
1905	347,747	529,645	.....	1916	380,211	1,034,498	20,526
1906	302,262	747,303	.....	1917	202,539	613,440	27,015
1907	343,085	956,958	.....	1918	198,539	818,962	9,346
1908	362,890	1,270,020	.....	1919	242,186	815,385	78,425
1909	351,491	1,224,822	.....	1920	334,704	900,000	145,072
1910	319,069	1,286,262	2,397	1921	372,019	1,455,239	122,024(c)

(a) Figures furnished by Charles Michel, Paris. (b) Estimate. (c) Production.
[1] Report furnished by the Department of Mines and Quarries, Egypt.

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Islands of the Pacific and Indian Oceans

The phosphate deposits which occur in several islands of the Pacific and Indian oceans are of the highest grade yet discovered. The most important phosphate-producing islands of the Pacific are Ocean Island (English) of the Gilbert group, the Island of Angaur (Japan) of the Pellew group, Tahiti and Makatea (French) of the Society group, and the Island of Nauru (English) of the Marshall group. According to late advices,[1] these latter two islands have a reserve supply of phosphate rock amounting to from 80,000,000 to 100,000,000 tons. This rock is reported to average about 85 per cent. bone phosphate of lime. Before the war Nauru and Ocean islands had a combined output of 350,000 tons per annum. It is estimated that the production in 1921 was 100,000 tons from Nauru and 200,000 tons from Ocean Island.

A report from Consul H. F. Withey states that phosphate is the only mineral produced in or exported from the Society Islands. It is produced and exported by one company, the Compagnie Francaise des Phosphates, a French corporation with head offices in Paris, and with a capital stock formerly of 6,000,000 francs, all French owned, except for a relatively small amount held in Tahiti. The capital stock is now 11,000,000 francs. This concern, organized in 1908, has the exclusive mineral rights of the island of Makatea, which is about 120 miles north of Tahiti and has an area of roughly 1200 acres. Two piers about 300 meters long, a part of which length, however, is on shore, have been constructed. Mooring buoys and lighters are used by the loading vessels. The phosphate runs about 80 per cent. bone phosphate of lime, according to the statement of the manager of the company. Before the war the annual production was from 80,000 to 90,000 metric tons. In 1919, 1920 and 1921 the annual production was approximately 40,000 metric tons. At present most of the phosphate from Tahiti is shipped to New Zealand.

No figures have been obtained showing the total production of phosphate on Christmas Island in the Indian Ocean 190 miles south of the western extremity of Java, but a report[2] states that a Japanese phosphate company purchased 60,000 tons of rock from this island in 1921.

In addition to the phosphate deposits of these islands, this mineral has recently been discovered in New Zealand, where the annual output is about 10,000 tons. Phosphate rock is also reported scattered over a wide area in Australia. This rock ranges all the way from 50 to 70 per cent. bone phosphate of lime. The higher grades are being used for the manufacture of acid phosphate and the lower grades are finely ground for direct application to the field. Statistics showing the production

[1] *Am. Fert.*, Apr. 22, 1922.
[2] "Japanese Acid Phosphate Industry," *Am. Fert.*, Apr. 8, 1922.

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from the South Sea islands are very incomplete, but as near as can be learned at present their combined annual output is fully 450,000 tons.

EUROPE

Russia.—Large deposits of phosphate occur in three regions of Russia, but prior to the war the deposits had been developed only by the Governments of Podolia and Bessarabia. These deposits are of considerable importance to European agriculture, and since they lie close to the old Austrian frontier, the Central Empires no doubt availed themselves of these fields to meet, in part, the shortage of phosphate fertilizers caused by the cutting-off of the supply normally imported from the United States and Africa. It has been estimated that the deposits in southern Russia so far developed contain 80,000,000 tons of phosphate.

In a recent report by A. V. Kazakoff[1] on the conditions existing in certain phosphate fields in the central and southern districts, it is stated that these deposits are being exploited by the Soviet Government and it was the intention to produce 9800 tons in 1921.

France and Belgium.—The phosphate deposits of France and Belgium at one time largely supplied Europe's demand for phosphate fertilizers, but the annual production from these sources just prior to the war had fallen off to such an extent that the output was only a very small percentage of the world's production. This decrease was due in part to the depletion of the deposits but chiefly to the development of higher-grade and more easily mined deposits in other countries. Since France controls the deposits of phosphate in Tunis and Algeria, she is drawing her main supply from those sources. Belgium still continues to produce a small tonnage of phosphate and phosphate chalk, the amount in 1920 having been 133,040 metric tons and in 1919, 90,970 tons.

TABLE VIII.—FRENCH IMPORTS AND EXPORTS OF PHOSPHATE ROCK
(In metric tons)

Year.	Imports.	Exports.
1912	903,489	22,062
1913	934,688	21,128
1914	661,429	11,219
1915	325,114	1,796
1916	285,906	1,437
1917	134,779	627
1918	233,399	36
1919	502,640	1,517
1920	827,321	3,280
1921	708,902	...

Germany.—Although Germany has been one of the greatest phosphate-consuming nations in the world, up to the time of the European war there were no known deposits of phosphate rock within her borders. Prior to the war, however, this nation had very valuable resources of

[1] "Russian Phosphate Mining Reviving," *Am. Fert.*, Apr. 8, 1922.

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phosphate in certain of her insular possessions (notably Ocean, Nauru, and Angaur islands), but these islands have now passed into the hands of England and Japan. During the war Germany was obliged to depend chiefly on basic slag (a by-product obtained in the manufacture of steel) to meet her agricultural requirements, but even with the increased production of this material due to the stimulation of the steel industry, the supply of phosphatic fertilizers fell considerably short of the demand.

In 1918, however, a deposit of phosphate was discovered close to Amberg in Bavaria. The material is reported to be in the dibasic form, but this appears very doubtful to the writer. The average grade of the phosphate is said to be equivalent to 35 per cent. bone phosphate of lime, which is hardly sufficiently high to warrant exploitation unless the material can be concentrated.

England.—While phosphate in the form of coprolites has been found in various parts of the British Isles, the deposits have not been of sufficient importance to meet the demand of that country for phosphatic fertilizer and production has now practically ceased. The annual output of superphosphate in England is about 800,000 long tons. Most of the rock used in the manufacture of this superphosphate is imported from Tunis.

England, however, not only controls important deposits of phosphate rock in Egypt, but owns the exceptionally rich deposits on Ocean, Nauru and Christmas islands. Relatively little of the rock from these latter sources, however, is actually shipped to the British Isles. England also has a large annual output of basic slag which is a useful supplement to superphosphate for fertilizer purposes.

The statistics showing the imports and exports of fertilizers by England as far as the figures are available are given in Tables IX and X.

TABLE IX.—IMPORTATIONS OF PHOSPHATIC MATERIALS TO ENGLAND
(Metric tons)

Material.	1916.	1917.	1918.	1919.	1920.
Basic slag	.....	.....	100	1,724	.....
Guano	(a) 21,991	(a) 2,643	.....	103	.....
Phosphate rock	(a)338,721	(a)281,056	(a)472,205	357,463	531,776
Total	360,712	283,699	472,305	359,290	531,776

(a) Includes Ireland.

TABLE X.—EXPORTATIONS OF PHOSPHATIC MATERIALS FROM ENGLAND
(Metric tons)

Material.	1916.	1917.	1918.	1919.	1920.
Superphosphate	(a)14,760	(a)3,284	2,588	4,091	11,914
Phosphate rock	.....	.....	.....	.....	.....
Basic slag	(a)39,248	(a)1,854	1,082	13,919	.....
Total	54,008	5,138	3,670	18,010	11,914

(a) Includes Ireland.

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Spain.—The only phosphate deposits in Spain of any commercial importance are apatite veins at Aldea Moret in the province of C'aceres. According to the latest available statistics 24,633 long tons was produced from this source in 1919. Most of the phosphate rock used in Spain, however, is imported from the United States, Tunis and Algeria. The imports as far as the figures are available are shown in Table XI.

TABLE XI.—IMPORTS TO SPAIN
(In metric tons)

Material.	1917.	1918.	1919.	1920.	1921.
Phosphate rock	(a)126,266	115,028	115,986	243,165	280,164
Basic slag					
Superphosphate	(b)12,106	11	5,605	(b)54,515	(b)78,170
Guano	2,398	988	(c)1,835		

(a) January to October. (b) Includes basic slag. (c) First 11 months.

Asia

Japan.—Low-grade phosphates have been worked for a number of years in the provinces of Noto, the Bonni Islands, and also in Formosa, but the output from these sources has been entirely too limited to meet the demands of Japan for phosphoric acid. A fair grade of phosphate rock, however, was discovered a few years ago on Rasa Island, one of the Loochoo group of islands, and a considerable tonnage is now annually produced from this source. This phosphate, however, has such a high percentage of iron and aluminium oxides as to render the manufacture of acid phosphate therefrom rather difficult. Japan also controls the phosphate mines on Angaur Island of the Pellew group and the deposits on several of the Marshall islands. All of these deposits were formerly owned and operated by German capital. The latest available figures on the Japanese output are for 1919 and show a production of 120,893 metric tons, which was a little less than half of that consumed the same year. The balance was made up by imports from the United States, Egypt and phosphate-producing islands in the Pacific Ocean.

The imports of phosphate rock to Japan are given in Table XII.

TABLE XII.—IMPORTS OF PHOSPHATE ROCK TO JAPAN

	Metric Tons.		Metric Tons.
1913	328,580	1918	89,572
1914	266,922	1919	191,537
1915	135,800	1920	281,200
1916	99,702	1921	210,000
1917	155,446		

Technology

During the past year increasing interest has been evinced in pyrolytic methods of producing phosphoric acid without the aid of sulphuric acid. Two concerns in the South are producing phosphoric acid by smelting

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mixtures of phosphate rock, silica, and coke in the electric furnace, and at least one of these is operating on a relatively large commercial scale. Whereas formerly this company produced phosphoric acid merely as a by-product in the manufacture of ferrophosphorus, such progress has been made during the past two years that phosphoric acid can now hardly be considered a by-product, since the ingredients in the furnace charges are so proportioned as to give a high yield of this acid. The phosphoric acid thus obtained has been found to be very pure and is not only being sold as such, but is manufactured into phosphate salts for various chemical and industrial purposes.

The Briquetting of Mineral Phosphates.[1]—In connection with the production of phosphoric acid by the volatilization method, it was deemed necessary to conduct investigations on methods of briquetting mineral phosphates so that much run-of-mine material and disintegrated phosphate rock might be utilized in furnaces of the shaft type. The Bureau of Soils has had this problem under investigation for several years and has found that many deposits of phosphate in Tennessee and Florida may be utilized in this way. Such a method not only makes it possible to employ phosphates which because of their physical condition could not otherwise be used, but also eliminates a large proportion of the waste now going on because of the methods employed in preparing high-grade rock for the market. In a number of cases the silica content of the run-of-mine phosphate rock is such that very little additional sand need be added to give the proper silica-lime ratio for the most efficient volatilization of phosphoric acid in the furnace. Furthermore, by including in the briquetted mass the coke or other carbonaceous material necessary for the reduction of the phosphoric acid, a much more rapid and efficient reduction is attained.

Sintering Process of F. S. Washburn.[2]—With the same idea in view, namely that of putting run-of-mine phosphate in a suitable physical condition for furnace-treatment, Washburn proposes to sinter a mixture of phosphatic material, silica, and carbonaceous matter at a temperature insufficient to volatilize any phosphoric acid. The porous mass thus obtained may be used in an electric furnace of the shaft type or in a combination furnace wherein the sensible heat evolved in the gases is utilized by passing said gases through the sintered mass contained in a chamber, shaft, or kiln adjacent to the electric crucible. The porous nature of the sinter makes it feasible to drive or suck the phosphoric acid and gaseous products through the incoming phosphatic charge.

Sodium Phosphate from Phosphate Rock.[3]—In a patent taken out by

[1] W. H. Waggaman, H. W. Easterwood, and T. B. Turley, *Chem. Met. Eng.*, **23**, 1057 (1921).
[2] U. S. Pat. No. 1,373,471 (1921).
[3] U. S. Pat. No. 1,375,115 (1921).

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Walter Glazer of Brooklyn, N. Y., and assigned to the Potash Extraction Corporation of New York, N. Y., the inventor proposes to submit a mixture of finely ground phosphate rock, sodium carbonate, and carbon with or without the addition of silica to a temperature between 600 and 700° C. It is claimed that no phosphoric acid is evolved at these temperatures from such mixtures, but that the following reactions take place:

(1) $Ca_3P_2O_8 + 3Na_2CO_3 + 3C + 3O_2 = 3CaCO_3 + 2Na_3PO_4 + 3CO_2$

(2) $3SiO_2 + 3Na_2CO_3 + Ca_3P_2O_8 + 3C + 3O_2 = 3CaSiO_3 + 2Na_3PO_4 + 6CO_2$

The resulting soluble phosphate is leached out with water and is then subjected to the action of carbon dioxide. This can be conveniently accomplished by passing the products of combustion obtained in the first step through the solution. These two latter steps may be graphically represented as follows:

(1) $2Na_3PO_4 + 2H_2O = 2Na_2HPO_4 + 2NaOH$

(2) $2Na_2HPO_4 + 2NaOH + CO_2 = 2Na_2HPO_4 + Na_2CO_3 + H_2O$

The dibasic sodium phosphate formed by the treatment of the solution with carbon dioxide is then separated from the carbonate by crystallization.

Process and Apparatus for Calcining Phosphate Rock.[1]—Mark Shoeld has invented a process and apparatus for the calcination of phosphate rock and the rendering of phosphoric acid contained therein citrate-soluble. A slurry of sodium sulphate and phosphate rock in water is injected by means of a suitable nozzle through the lower end of a rotary, inclined, internally fired kiln, directly into the central heat zone of the kiln, which is maintained at temperatures of 1100 to 1400° C. It is claimed that this sudden and almost instantaneous introduction of the slurry into the highly heated chamber prevents in a large measure certain objectionable results which would occur where the material is more gradually raised to the reaction temperature. It is also stated that the presence of water prevents the objectionable initial sintering of the charge because of the rapidity with which it is converted into steam which at the higher temperature assists in the chemical reaction. By introducing the mixture into the furnace in a steady but relatively small stream, the direction of which can be changed at will, it is claimed that the necessary temperature may be reached in from 1 to 5 sec. and a product containing a uniform proportion of available phosphoric acid obtained. An apparatus for manufacturing this soluble phosphate is illustrated. This process and apparatus are assigned to the Armour Fertilizer Works of Chicago, Ill.

[1] U. S. Pat. No. 1,393,840 (1921).

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Soper's Process.[1]—With the same end in view, that is, to produce a citrate-soluble phosphate, Ellis C. Soper proposes to briquet a mixture of phosphate rock, carbonaceous material, and salt of an alkaline metal such as sodium sulphate, and introduce these briquets into a rotary kiln heated to between 1000 and 1450° C. The advantages claimed in the mixing of the fuel with the phosphate and alkali-metal salt are: First, better fuel economy due to the intimate contact of the combustible material to be treated; second, an increase in the rapidity of decomposition of the alkali-metal salt. A convenient form of rotary kiln is suggested.

Method of Making Ammonium Phosphate.[2]—H. C. Hetherington and J. M. Braham in a public-service patent issued Feb. 22, 1921, propose a method of making mono-ammonium phosphate which consists in passing ammonia gas into concentrated phosphoric acid containing at least 60 per cent. H_3PO_4, the rate of introduction of ammonia being sufficient to elevate the temperature of the mixture to at least 105° C. and the quantity of ammonia introduced being such as to almost but not quite correspond to that required by the formula $(NH_4)H_2PO_4$. The mono-ammonium phosphate is readily crystallized and separated from the adhering mother liquor in some well-known manner such as centrifuging. The method of fixing ammonia by means of phosphoric rather than sulphuric acid has a number of advantages: First, phosphoric acid is an essential fertilizer ingredient, whereas sulphuric acid is not; second, the pyrolytic method of producing phosphoric acid promises to be widely employed in the not far distant future and it is logical to so treat the acid thus produced to obtain a product in which both the acid and base have a distinct market value; third, a great saving will be effected in the transportation of relatively valueless filler and labor charges will be materially reduced because of the handling and distribution of a high-grade concentrated product.

Process of A. L. Kreiss.[3]—With a view to producing both available phosphoric acid and potash this inventor suggests the heating of an intimate mixture of phosphate rock, a potassium-bearing silicate, and sodium sulphate (with or without the addition of soluble potash salts) in a rotary kiln or some other suitable form of furnace directly or indirectly fired. After calcining, the resultant mass is said to contain water-soluble potash and citrate-soluble phosphoric acid, and may be applied directly to the soil after crushing or other suitable preparation. No particular temperature is specified by the inventor and no equations given showing the reactions or chemical changes which take place. This process is very similar to a number of others which have been proposed from time to time.

[1] U. S. Pat. No. 1,396,149 (1921).
[2] U. S. Pat. No. 1,369,763 (1921).
[3] U. S. Pat. No. 1, 366, 569 (1921).

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PLATINUM

By George F. Kunz

The platinum industry did not suffer greatly from depression as did other metals and minerals in 1921, except to some extent as regards prices. Statistics show a 37-per cent. increase in production of refined platinum and allied metals in the United States and a 25-per cent. increase in consumption. Prices had declined greatly from the high figures reached in the past few years on account of the war demand and the virtual stoppage of production in Russia, but nevertheless held very even through the year and showed some increase in the latter part. The average price was 33 per cent. lower than the average for 1920, but 67 per cent. higher than in 1913. There is an apparent upward tendency for 1922.

AVERAGE MONTHLY PRICES OF PLATINUM AT NEW YORK
(In dollars per troy ounce)

	1913.	1914.	1915.	1916.	1917.	1918.	1919.	1920.	1921.
January.....	45.50	43.38	41.10	90.05	87.83	105.92	104.85	154.23	73.40
February.....	45.50	43.50	40.00	90.00	103.75	107.68	100.43	151.59	70.23
March.....	45.50	43.50	39.50	90.75	104.33	108.00	99.20	138.56	72.46
April..... ...	45.50	43.50	38.63	83.10	103.77	108.00	99.85	127.04	73.40
May.....	45.50	43.50	38.50	80.50	105.00	106.27	102.60	97.50	73.74
June.....	45.50	43.50	38.00	78.13	104.75	105.00	105.80	85.19	74.94
July.....	45.50	43.50	38.00	63.60	103.88	105.00	105.90	83.94	70.44
August.....	44.90	50.20	39.25	62.56	104.55	105.00	107.60	111.44	73.22
September....	43.96	50.00	50.00	84.25	104.13	105.00	128.70	115.20	75.96
October.....	44.00	49.50	54.50	89.75	104.00	105.00	132.21	101.70	81.80
November....	43.70	45.45	62.63	101.25	104.52	105.00	136.74	84.75	82.60
December.....	43.45	42.19	85.50	86.87	104.38	105.54	151.35	79.62	78.19
Year.....	44.88	45.14	47.13	83.40	102.82	105.95	114.61	110.90	75.03

United States Production of Platinum and Allied Metals

Crude Platinum.—Miners reported to the United States Geological Survey a production of 538 troy oz. of crude platinum in 1921, distributed by states as follows: California, 387 oz.; Oregon, 83 oz.; Alaska, 65 oz. Refiners report the purchase of domestic crude platinum in the following quantities by states: California, 847 oz.; Oregon, 96 oz.; Alaska, 78 oz. They also report the purchase of 56,654 oz. of foreign crude platinum, of which 55,286 oz. was from Colombia, South America; 63 oz. from Canada; and 1286 oz. of Russian origin.

New Refined Platinum Metals.—Refiners report a large increase in the recovery of new platinum metals in 1921. The greatest increase was in

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platinum. Of the metals recovered in 1921 by refiners, about 4800 oz. was obtained from domestic material.

NEW PLATINUM METALS RECOVERED BY REFINERS

Year.	Platinum.		Iridium, Troy Os.	Osmiridium, Troy Os.	Palladium, Troy Os.	Rhodium, Troy Os.
	Troy Os.	Grams.				
1915	6,495	202,107	274	335	1,541	.....
1916	24,518	762,596	370	315	2,885	.....
1917	33,009	1,026,695	210	833	4,779	.....
1918	54,399	1,691,999	465	539	4,024	326
1919	40,220	1,250,983	401	402	3,807	279
1920	36,015	1,120,175	418	409	4,309	393(a)
1921	51,791	1,610,881	286	581	2,686	1,026(a)

(a) Includes osmium.

Secondary Platinum.—Platinum metals recovered from scrap and other old material form an important part of the supply. The total quantity recovered in 1921, 45,794 oz. is about 20 per cent. less than that recovered in 1920.

SECONDARY PLATINUM AND ALLIED METALS SOLD (a)
(Troy ounces)

Year.	Platinum.	Iridium.	Palladium.
1915	42,149	863	958
1916	45,156	1,535	1,284
1917	59,007	9,832	3,347
1918	40,378	3,410	1,795
1919	54,545	3,504	3,467
1920	51,255	3,355	3,100
1921	39,131	1,776	4,887

(a) U. S. Geol. Surv.

STATISTICS OF PLATINUM IN THE UNITED STATES

Year.	Production. (a)		Imports.			Total.
			Unmanufactured. (b)		Manufactured.	
	Troy Os.	Value.	Troy Os.	Value.	Value.	Value.
1904	200	$4,160	103,802	$1,812,242	$105,636	$1,922,038
1905	318	5,320	104,196	1,985,107	188,156	2,178,583
1906	1,439	45,189	137,556	3,601,021	187,639	3,833,849
1907	357	10,589	74,208	2,509,926	175,651	2,696,166
1908	750	14,350	50,768	1,096,615	134,119	1,245,084
1909	638	15,950	118,851	2,557,574	410,997	2,984,521
1910	773	25,277	120,478	3,320,699	333,965	3,679,941
1911	940	40,890	122,390	4,722,752	135,842	4,899,484
1912	1,005	45,778	104,683	4,334,488	159,995	4,540,261
1913	1,034	46,530	117,947	4,938,706	105,553	5,090,789
1914	3,430	154,350	72,267	2,934,580	39,143	3,128,073
1915	6,495	322,347	61,437	2,340,476	71,532	2,734,355
1916	24,518	2,044,801	53,484	3,138,396	18,923	5,202,120
1917	33,009	3,393,985	30,316	2,414,773	382	5,809,140
1918	54,399	5,763,574	54,962	4,949,755	14,225	10,727,554
1919	40,220	4,609,614	54,550	5,229,309	17,213	9,856,136
1920	36,015	3,994,064	80,955	8,474,499	94,408	12,562,971
1921	51,791	3,885,879	61,941	4,115,235	28,524	8,029,638

(a) Statistics of the U. S. Geol. Surv. New platinum only, recovered by refiners. (b) Includes ingots, bars, plates.

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IMPORTS

Refined platinum metals are imported in considerable quantity, as well as crude platinum, which is bought by domestic refiners. The imports decreased about 22 per cent. in quantity in 1921, and nearly 50 per cent. in value.

IMPORTS OF THE ALLIED PLATINUM METALS INTO THE UNITED STATES FOR THE YEARS 1919–1921

	Troy Os.	Grams.	Value.	Aver. per Os.	Aver. per Gram.
1919.					
Iridium	5,808	180,646	$975,174	$168.24	$5.40
Osmiridium	1,374	42,736	112,403	81.81	2.63
Osmium	2,339	72,750	132,097	56.47	1.82
Palladium	3,739	116,294	250,777	67.07	2.08
Rhodium	222	6,905	30,474	137.27	4.43
1920.					
Iridium	4,718	146,744	$726,502	$153.99	$4.95
Osmiridium	4,473	139,124	450,241	100.66	3.24
Osmium	593	18,544	39,517	66.64	2.13
Palladium	6,944	215,979	612,248	88.17	2.83
Rhodium	2,053	63,854	217,385	105.88	3.24
Ruthenium	29	902	2,640	91.03	2.93
1921.					
Iridium	1,345	41,841	$277,597	$204.50	$6.64
Osmiridium	2,603	80,974	296,277	113.82	3.66
Osmium	161	5,009	13,239	81.89	2.64
Palladium	11,348	352,962	629,965	55.51	1.78
Rhodium	609	18,942	53,350	87.62	2.82
Ruthenium	152	4,728	4,268	28.08	0.90

CONSUMPTION

The total consumption of platinum metals in the United States in 1921 was 176,148 troy ounces, an increase of about 25 per cent. as compared with the consumption in 1920. Dentists and jewelers increased their use of platinum; the chemical and electrical industries decreased its use.

CONSUMPTION OF PLATINUM IN THE UNITED STATES BY INDUSTRIES
(In troy ounces)

Industry.	Platinum.	Iridium.	Palladium.	Total.	Percentage of Total.
1920.					
Chemical	13,226	43	240	13,509	9.58
Electrical	23,029	2,673	1,784	27,486	19.49
Dental	6,413	114	8,898	15,425	10.94
Jewelry	77,267	3,108	593	80,968	57.40
Miscellaneous	3,119	116	418	3,653	2.59
	123,054	6,054	11,933	141,041	100.00
1921.					
Chemical	12,273	34	45	12,352	7.02
Electrical	20,574	1,003	7,626	29,203	16.58
Dental	13,181	75	8,501	21,757	12.35
Jewelry	101,258	2,367	1,265	104,890	59.55
Miscellaneous	3,791	3,938	217	7,946	4.50
	151,077	7,417	17,654	176,148	100.00

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Stocks.—The stocks of platinum metals in the hands of refiners at the end of 1921 were 67,660 troy oz., as compared with 67,508 oz. at the end of 1920.

STOCKS OF PLATINUM METALS IN HANDS OF REFINERS
(In troy ounces)

	Platinum.	Iridium.	Palladium.
1920	46,747	4,196	16,565
1921	38,514	4,991	21,042

The Ordnance Salvage Board on June 29, 1921, issued circulars for a proposed sale of 34,150 avoirdupois pounds of surplus platinum mass. However, the sale did not take place, as it is the intention of the War Department to retain the material in the war reserve. It is noted that this platinum mass was prepared for use in the contact system of sulphuric-acid manufacture, and it is stated to consist of epsom salts sprayed with platinic chloride.

The circular divides the material into four lots, as follows:

Lot No. 1, approximately	5,850 lb	0.30 per cent. platinum
Lot No. 2, approximately	4,400 lb	0.20 per cent. platinum
Lot No. 3, approximately	16,900 lb	0.15 per cent. platinum
Lot No. 4, approximately	7,000 lb	0.30 per cent. platinum

The platinum content according to these figures would be:

Lot No. 1	255.94 troy oz.
Lot No. 2	128.33 troy oz.
Lot No. 3	369.69 troy oz.
Lot No. 4	308.50 troy oz.
Total	1,062.46 troy oz.

There has been some agitation favoring certain modifications of the platinum legislation recently enacted in New York and Illinois. Many jewelers object strongly to any admixture of palladium instead of iridium with platinum, for the price of palladium ($55 to $60 per oz. on May 3, 1922) is only about one-third of that of iridium ($150 to $170 per oz. on the same date); moreover, the great difference in specific gravity (palladium 11.4, iridium 22.38) provides a much larger bulk for the same price. Very many manufacturers and dealers are opposed to the use of any admixture except iridium in the making of "hard platinum;" they would prefer to have "hard platinum" defined by law as platinum with an admixture of 10 per cent. of iridium, and they would like to have all other alloys prohibited. However, it is always possible for the jeweler to obtain precisely the kind of "hard platinum" he wishes, by simply specifying this in his order to the manufacturer. Should articles furnished by the latter not be in accord with the specification, it would constitute a fraud upon the purchaser, and could be punished as such. Thus the present law makes it possible for the jeweler to secure exactly what he

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bargains for, and yet leaves to those who do not sympathize with this restriction the freedom they have a right to expect.

It has been suggested by the present writer, as a member of the Committee on Platinum Theft Control, that the United States should refine all the platinum in its possession, should state the amount of this refined product, and should place it in the care of the Bureau of Standards to be loaned to those pursuing scientific investigations in the United States and not having the available means for securing platinum. The title of the metal should, of course, remain with the Government of the United States, and it should be subject to its call at any time. Platinum being such a rare and costly metal, it seems as though chemists in universities or institutions of learning should not be forced to buy it for their investigations, when there exists, in Government possession, a stock for which there is no present use. By means of this action, the platinum would be utilized, and at the same time the Government would have a stock at its disposal, in case any need for it should arise, at a moment's notice.

Platinum Mining in the United States

Alaska.—The platinum output of Alaska in 1921 was very much smaller than it was in 1920. In that year, 1479 oz. of platinum and the other platinum minerals was produced in the territory, while in 1921 but 65 oz. was recovered. This was largely owing to the fact that all work was suspended in the Salt Chuck palladium-copper mine, which has been the chief source in Alaska. The small quantity of platinum found in 1921 came entirely from gold-placer mining, chiefly on Dime Creek, on Seward Peninsula.

The past production of the Alaskan properties of the Platinum, Palladium Producing Corporation is given as follows:

	Ounces.
Platinum and palladium	2,267.83
Gold	1,649.43
Silver	10,274.08

In addition 1,029,150.71 lb. of copper was produced.

Two well-defined bodies of ore have been opened up sufficiently to show their value and extent as far as the 300-ft. level; it is here that work is at present being done. From the Glory Hole body about 49,000 tons of ore has been mined and it has been followed down to below the 150-ft. level. The body adjoining the Glory Hole has been stripped on the surface for a space of 80 by 120 ft., and has been traced from the 300-ft. level to within about 60 ft. of the surface. These two bodies are expected to furnish enough ore to supply the mill for six or seven years' operations

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at full capacity. When this supply has been exhausted to the 300-ft. level, other bodies known to exist will be opened up and will furnish the mill with ore for many years to come.[1]

California.—It is estimated that 500 fine oz. of platinum was recovered in California in 1921, the value being $45,000.[2] The platinum-group metals are produced chiefly by the gold dredges in Shasta and Trinity counties. The principal diggings were along Beegum Creek on the Shasta-Tehama county line, and on the lower South Fork of the Trinity River near Hyampom. In the Beegum Creek assays the native metal gave from 13 to 20 per cent. platinum, and 75 to 85 per cent. osmiridium, the high ruling price for iridium enabling some miners to earn as much as $20 a day. It is expected that in 1922 machinery will be put in on Beegum Creek, and that the production will be considerably increased. The total output for 1921 equals or slightly exceeds that for 1920.[3]

In the Auburn district of California, iridium and platinum are produced from gold-dredging operations on Yuba, American and other rivers, and occasionally from the drift mines, but no property is worked exclusively for these metals. The platinum metals found in dredging on American River seem to contain a greater proportion of iridium than is the case in other parts of the field.[4]

Oregon.—In southwestern Oregon platinum, like chromite, is associated with serpentine. The gravel deposits of this region, nearly all of which contain the native alloy of platinum, iridium, and osmium, are apparently derived from the serpentine. This means that these metals are believed to be the primary constituents of the igneous rock and have altered into serpentine. The belief also prevails that the ultimate source of the gold placers in this region, like those of California, is in the serpentine- and olivine-bearing rocks of the Sierra Nevada and tributary ranges. In but few cases has the platinum which is associated with the gold in the placer workings of the district been traced to lode deposits containing the metal in the native form. A phenomenon indicating proximity to its source is a roughness of the platinum, and in certain specimens a black or a brownish coating. In the Riddle Quadrangle the serpentines have resulted chiefly from the decomposition of the peridotites and the pyroxenites; in some areas, however, they are probably derived from the decomposition of the basic phases of the greenstone. Serpentine, derived in part from dunite, is abundant on Red Mountain, a name derived from the color of the thoroughly oxidized soils coming down from it and similarly highly ferruginous rocks. On the eastern

[1] Platinum, Palladium Producing Corporation, pamphlet issued Oct. 14, 1921.
[2] "Mining in California," Jan., 1922, Calif. State Mining Bureau, p. 32.
[3] "A Review of Mining in California during 1921," Calif. State Mining Bureau, Prelim. Rept., No. 8, p. 13, Jan., 1922.
[4] *Idem*, p. 42

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part of the mountain, some of the serpentine is derived from the alteration of amphibolite.

The smelter report on a shipment of concentrates from the Highland mine, in the Gold Hill district, rather puzzled the manager, for besides showing 14.12 oz. of gold and 3.24 oz. of silver, it also gave 0.32 oz. of platinum, the ore having been taken on the 100-ft. level of the mine. The Highland group of mines is located, according to Parks and Swartley of the Oregon Bureau of Mines, about 12 miles to the southwest of Gold Hill, on the right-hand fork of Foote Creek, at an elevation of 2600 ft. These deposits were first worked some 25 years ago. At present the workings are restricted to the oxide zone, while the older workings were more extensive. The strike of the vein is northeast and it dips south 35° east; the country rock is a micaceous sandstone. In an attempt to discover the source of the platinum, the owners found in the shipment the walls of the vein, but no trace of platinum. Therefore they turned to the vein matter as the source. This is mingled with quartz of three hues, namely, rose, amber and blue. The last named, denser than the others, is pitted with small cavities, lined with a sooty black mineral, and filled with decomposed ferrous matter. On crushing and panning this blue quartz, it invariably yielded a high percentage. On the other hand, the rose and amber quartzes show no platinum.[1]

Surprising amounts of platinum in quartz were found two years ago in Curry County, Oregon, the results running from 10 to 20 oz. per ton. The claim is made that these deposits have been traced for nearly 20 miles from northeast to southwest, ending in the vicinity of the mouth of the Sixes River. The possibilities of finding platinum in this river were written of by Diller in a paper published almost 20 years ago.[2]

Platinum in Other Countries

Albania.—It has been stated by Constantine A. Chekrezi, Commissioner from Albania to the United States, that platinum was discovered there very recently by Professor Saderholm of the University of Helsingfors, who was in Albania on a mission for the League of Nations.[3]

Australia.—The total Australian exports of platinum and osmiridium in 1921 are thus given in an official report:

Osmiridium	1,997 ounces
Native platinum	363 ounces
Platinum	84 ounces

[1] This, and the preceding and succeeding paragraphs are taken from A. E. Kellog's "Platinum in the Quartz Veins of Southwest Oregon," *Eng. Min. Jour.-Press*, 113, 1000 (1922).
[2] U. S. Geol. Surv., Folio 89, p. 6, 1903.
[3] *Eng. Min. Jour.-Press*, Apr. 1, 1922.

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Queensland.—It has been very truly said that in prospecting for platinum or platinum metals, the searcher should not merely have had experience in noting the presence of grains of platinum, osmiridium, etc., but should also have some knowledge of the formations in which platinum is likely to be present, that is to say that he should have some familiarity with the petrography of the platinum-producing regions. Unfortunately, the mere presence of platinum, however well established, does not suffice to make exploitation profitable, and this fact can hardly be determined without a consecutive and costly test. Among the localities in Queensland, Australia, which merit the attention of prospectors, are those in the neighborhood of Camarral, Canoona and Marlborough, near the coast and to the north and northeast of Rockhampton. In this region there is a great serpentine area; it is generally auriferous, and also contains chromite deposits, and thus the geological conditions seems to point rather clearly to the presence of platinum. Other serpentine areas are at Kilkivan, Marodian and Black Snake, where in some of the lodes, gold, copper, nickel, cobalt and manganese are present, and the Fat Hen and Angella creeks, where the presence of platinum has been recently reported, are also in a serpentine and schist region. At Mount Pring near the port of Bowen, the presence of serpentine was determined some time ago, and as chromite seems to exist in the gravels of the watercourses, there may well be alluvial concentrates containing platinum. Other possible sources would be the Peak Downs copper mine at Copperfield, near Clermont, with its serpentine schist formations, and the serpentines at Herberton, Koorboora and Watsonville in North Queensland as well as the Calliope and Mount Rainbow goldfields in the Gladstone district. The same holds good of the copper deposits at Mount Chalmers and Warminster. There is close to the latter a serpentine outcrop and in the mine a serpentinous slate is associated with the copper sulphides and oxides; the slates in both localities contain much baryte. Hence, it is quite probable that the platinum may be associated with the gold-area copper.[1]

Tasmania.—Of late years Tasmania has been one of the chief sources for osmiridium, almost all of it coming from alluvial deposits. It has been established that its occurrence is ultimately related to the chemical and physical characters of serpentine rocks, but an imperfect knowledge of the deposits which undoubtedly exist has interfered with a profitable utilization of them. Serpentinized peridotite (olivine and bronzite) contain osmiridium, while it fails to appear in serpentine resulting from pyroxenites and gabbros. It does not seem to be finely disseminated, but to occur in irregularly distributed pockets along the structural planes of the rock. This irregular distribution makes it impossible to estimate

[1] B. Dunstan, "Platinum, Its Occurrences and Treatment," *Queens. Govt. Min. Jour.; So. Afr. Min. Eng. Jour.*, Mar. 26, 1921.

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the value of a given mass of rock and operates to discourage the erection of large plants for exploitation.[1]

The amount of osmiridium produced in Tasmania in 1921 was 1751 oz., of a value of £42,935, or £24 10s. per oz. In 1920 it was 2009 oz. valued at £77,114, or £38 8s. per oz.; and in 1919 it was 1669 oz. worth £39,614, or £23 15s. per oz.

Brazil.—It has recently been reported that platinum has been discovered in the State of Parahyba do Norte, Brazil, on a mountain ridge three miles from the main automobile road leading from Campiña Grande to Patos. It is understood that a branch road could easily be constructed from the track line now regularly operating over this line, to the place of the deposits. Until this shall have been accomplished, the present owner proposes to establish an extracting plant and have ore taken away by truck.[2] The region of this deposit is owned by Dr. Freire, Jr., who controls one square league of territory and believes that this territory covers the platiniferous area. He reports that the platinum is in ferruginous rock, and that preliminary tests show that the rich ore yields as much as 38 grams per ton.

Canada.—Gold- and platinum-bearing sands have been discovered along the Red Deer River, about nine miles from the town of Erskine, Alberta, Canada, and claims are being staked out. As assay of material secured from a test pit sunk 25 ft. to bed rock showed the following averages per cubic yard: Gold $3.96; platinum $1.75. The finding of platinum, in leaves or plates, at a depth of about 500 ft. in Douglas Channel mine, formerly known as the Drum Lummon, has been reported in the press, but no information has been secured as to the quantities obtained, nor has any confirmatory data come to hand. The British America Nickel Corporation, which began operating its refinery at Deschenes, Quebec, early in 1920, closed it down in 1921, but expects to resume work there before long. Leaving out of account the product from Mond matte exported to Wales, on which no data have recently been issued, the Canadian production for 1921 amounted to 296 oz. Besides this there was produced of the allied metals 591 oz. of palladium and a total of 56 oz. of iridium, rhodium, ruthenium, and osmium. From the alluvials of British Columbia, only 8 oz. was reported. The Ontario output was produced in part by the Deschenes plant refining Sudbury matte, and was partly recovered in New Jersey by the International Nickel Co., treating residues from the Port Colborne refineries.[3]

The total production of platinum and platinum metals in Canada is given as follows for the years 1917–1920:

[1] *Queens. Govt. Min. Jour.*, June 15, 1921.
[2] *Comm. Rept.*, Apr. 3, 1922. From Consul C. R. Cameron, Pernambuco.
[3] Prelim. Rept. Min. Prod. of Canada, 1921, Dominion Bur. of Statistics.

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CANADIAN PLATINUM STATISTICS (*a*)

	1917.		1918.		1919.		1920.	
	Ounces.	Value.	Ounces.	Value.	Ounces.	Value.	Ounces.	Value.
Platinum production from alluvial sands	57	$3,823	39	$2,560	25	$2,150	17	$719
Platinum recovered at the Ottawa Royal Mint	18	1,663	16	1,456	23	1,990	15	775
Platinum metals recovered from treatment of Sudbury mattes:								
Platinum	.....	.....	.....	.....	25	1,447	89	5,665
Palladium	.....	.....	.....	.....	62	3,534	174	11,096
Rhodium, etc	.....	.....	.....	.....	.....	.....	20	1,249
Platinum metals recovered in United States from treatment of Sudbury mattes:								
Platinum	971	.....	650	.....	617	.....	489	.....
Palladium	1,354	.....	787	.....	762	.....	739	.....
Rhodium	325	.....	473	.....	227	.....	390	.....
Osmium, iridium and ruthenium	.....	.....	.....	.....	77	.....	102	.....
Imports of platinum as crucibles, wire, bars, etc	.....	$114,279	.....	$31,140	.....	$160,885	.....	$125,977
Exports of platinum in concentrates and "old scrap"	331	29,599	197	20,892	671	62,629	790	85,740

(*a*) Annual Rept., Min. Prod. of Canada, Can. Dept. of Mines.

Colombia.—The extent of the recovery of platinum in their deposits in Colombia is shown by the statement that in 1921 the South American Gold and Platinum Co. produced 14,053 oz. of platinum and 4501 oz. of gold. This was accomplished by two of the dredges, operating at about three-quarter capacity. The output was very notably larger than in the preceding year, 1920, when 6967 oz. of platinum and 1520 oz. of gold were secured by the operation of a single dredge.

UNITED STATES IMPORTS OF PLATINUM FROM COLOMBIA
(In troy ounces)

Year. (*a*)	Quantity.	Value.
1911	5,503	$147,820
1912	6,627	219,128
1913	10,461	363,731
1914	12,387	398,657
1915	13,601	470,938
1916	25,588	1,473,553
1917	21,278	1,536,422
1918	27,030	2,241,744
1918(*b*)	30,543	2,630,614
1919(*b*)	26,046	2,303,111
1920(*b*)	29,853	2,880,887
1921(*b*)	31,840	1,951,357

(*a*) Fiscal year ending June 30. (*b*) Calendar years.

Papua.—Osmiridium occurs in association with gold in Papua, formerly British New Guinea, and also in a free state. As was the case in Tasmania, the miners at first regarded it as worthless, for the mint authorities treated this alloy as a base metal, and objected to its presence

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in the gold bullion because of the defacement of the dies used in coining. The metal occurred either in a flaky form, or as granulets the size of small shot. Not long since a small consignment, weighing about 2½ lb., came to London from Papua, and was quickly purchased by the representative of an American firm for £1200, of course a much higher price than platinum commands, as iridium is much more valuable. The original discovery of the metal in Papua was made by some gold prospector who noted the presence of a bluish-gray metallic substance while washing the gravel from one of the river beds. A quick-witted engineer in the settlement when this was reported to him immediately divined that the substance was osmiridium, and urged the prospectors to return the next morning to the spot where they had found it. Heavy rains had fallen during the night and the swollen stream had washed away much of the precious gravel, but enough remained to realize a good round sum for the party when the osmiridium was marketed in London.[1]

Russia.—The recent official returns of platinum production in Russia under Soviet rule make but a sorry showing when compared with the state of things under the old régime. The following data have been compiled from the Soviet journal *Economic Life*, and cover the production in 1921 up to the end of August.[2]

Months.	Weight.[3]			
	Poods.	Pounds.	Zolotniks.	Dolias.
January to April (*Econ. Life*, June 14)	.....	31	23	76
May (*Econ. Life*, July 3)	1	6	85	48
June (*Econ. Life*, Aug. 12)	4	14	62	8
July (*Econ. Life*, Sept. 15)	2	23	37	26
August (*Econ. Life*, Oct. 29)	3	1	41	84
Total	11	37	58	50

This gives 6288 oz., which must be compared with an annual average of 172,000 oz. for the five years preceding 1914. The slowing-up began with the outbreak of the World War, for in 1914 it had already fallen to 157,000 oz., from which point it declined to 108,000 oz. in 1915, and to 79,000 oz. in 1916, with a slight recovery to 98,000 oz. in 1917. For the first six months of 1918 only 13,000 oz. of platinum was produced, but even this is twice as much as the output for the nine months of 1921 given above.

In the period before the World War, approximately 98 per cent. of the Russian platinum was refined in foreign countries. At the outset,

[1] *Min. Sci. Press*, Nov. 12, 1921.
[2] *Comm. Rept.*, Dec. 26, 1921.
[3] The pood equals 40 Russian pounds, or 526.6637 troy oz.; the zolotnik equals 13.1666 troy oz. and the dolia one 96th part of this.

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the bulk of this work was done at the well-known English platinum-refining establishment of Johnson, Matthey & Co., Ltd. However, early in the eighties of the last century, this firm was to a certain extent superseded by Heraeus & Co., of Hanau, Germany, and in 1909, they in turn yielded the first place to the Société Anonyme de l'Industrie du Platine, of Paris, and this became the great center of the industry, remaining so until the beginning of the war. At this period France refined 90 per cent. of the Russian output. As the possession of this monopoly was not favored by the Russian Government, a law was enacted in 1913 forbidding the export of crude platinum; but in July, 1915, this exportation was again permitted, subject to an export tax of 30 per cent. *ad valorem*, and single lots allowed to be sent were restricted to a value of 500 rubles (about $250), according to the price established by the State. An added restriction, proclaimed in February, 1917, prohibited the importation of drawn and spun platinum, in order to favor the founding of domestic refineries. The price fixed by the Government in 1916 was about $80.30 an oz., and by March, 1917, the miners were not content with this and later sales were reported up to about $110 an oz. for crude metal, 83 per cent. fine.[1]

Union of South Africa.—A possible platinum source has been found in the northeastern part of Cape Colony, which is known as the "Transkei," in an area about 80 miles north of Queenstown, around the villages of Cala and Ingobo, where the rocks are of the Stromberg series, a part of the Karoo series. This area lies about 2500 to 4500 ft. above sea-level, on one of the flanks of the Brakesberg Mountains. It is traversed by many valleys and gorges, water is plentiful, and the supply of native labor is abundant. The platinum recently found here occurred in certain of the diabase dikes near Cala, in the native state, and alloyed with iridium and other platinum metals, as well as with an amount of native iron. No notable associate minerals were found, with the exception of one of a deep amber color, most probably zircon or topaz. Very little pyrite was present and there were no traces of chromite or the other minerals which usually accompany platinum. Assays and panning of material taken in various spots, sometimes many miles apart, showed on an average several pennyweight per ton. Most of the platinum is in very fine grains, but some nuggets up to three grams in weight have been found. Part of the dikes are soft and decomposed, and the deposits can be worked cheaply by concentrating the sands and passing the slimes over blankets, or else using oil-flotation. It is not uninteresting to note that about 180 miles to the northward are the Insiza norites, and other intrusive rocks, recalling those at Sudbury, Ontario, Canada.[1]

[1] A. D. Lumb, "The Platinum Metals," London, 1920, p. 36.
[2] E. M. Watson, "Occurrence of Platinum in South Africa," *Eng. Min. Jour.*, Nov. 19, 1921.

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The presence of iridium in the Rand gold-mining region of the Transvaal is said to have been known for many years. It occurred in the banket reef, and was sometimes present in sufficient quantity in the mill black-sand concentrates to cause trouble for the gold assayers. No effort appears to have been made to extract the platinum metals in salable quantities until very recently. At the present time some osmiridium concentrate is recovered in the course of drilling operations in certain of the mines, and several ounces of the pure metals, iridium, osmium, ruthenium, platinum, and rhodium have been prepared in the Rand Mines laboratory.[1]

Occurrence of Platinum

A seventeenth-century writer stated, in speaking of precious stones, that nature had placed them sparingly, so that it would require great effort to obtain them. This surely applies to platinum, for it is found in many places, but never in any abundance, and much effort is required to locate it. As the writer has previously stated in a paper read before the American Institute of Mining Engineers, it is very probable that small amounts of platinum are being overlooked in ores of iron pyrite, chalcopyrite, pyrrhotite, certain ores of nickel, and especially in serpentine or in the alteration thereof. If all the mining engineers would make an occasional assay for platinum, and define their results by extending them out to the proper decimal, there might be good results.

As a summary indication of the great number of localities in which the presence of platinum and the platinum metals has been shown, the following list is offered, which has been made as complete as possible.

The World's Platinum Occurrences

Asia

India:
Near Bonai City, in gold washings.
Burma:
Irawaddy River.
Myitkyma, Burma Gold Dredging Co.
Patkoi Ranges, both on Assam and Burma sides; platinum and osmiridium.
Borneo:
Plaghary in Tanah-Laut.
Margalam, in river of that name.
Kalavran.
Hinoet.
Japan:
With irodosmine in the Yūbari-garva, the Pechan, and other rivers of Hokkaido. Also with gold and iron sand in Nishi-Mikawa, Province of Sado, and in Usotami, in the same mining district.

Africa

Rhodesia:
Somabula Forest, Gwelo district.
Great Dyke (norite) at head of the Umtebekwe Valley.
Willoughby's Halt, 12 miles south of Gwelo.

[1] Communicated by Mr. R. C. Cooper at a recent meeting of the Chemical, Metallurgical and Mining Society of South Africa.

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Cape Colony:
Insiswa, in copper-nickel deposits, eight miles north of Queenstown, in the villages of Ca!a and Ingobo.
Transvaal:
Klerksdorp and other gold-mining districts, in black sands.
Kromdaal, near Rostenburg, in samples of chromite.
Madagascar:
Northeast of Fenerive; the Manantsatrana and its affluents on the right, between the Tsalarasana and the Sasalasa (notably near Marosampana).
Right bank of the Bikera, and especially southeast of its entrance into the Marosampana.
Southwest of Vatomandry, west of Marosiky; the Sahanimora River, an affluent of the Vatana, notably near Ambia.
Near Ampasimpotsy, on the Tarafara, an affluent of the Manampotsy, to the westward of Anosibe.
The Isonjo, an affluent of the Manambiha, itself an affluent of the Mananara. It is in the neighborhood of Bemalaha that in 1904 platinum was found for the first time in Madagascar.

EUROPE

Russia:
In dunite deposits:
Rivers Omutnaya, Starchine-log, etc.
Tagil district: rivers Martian, Wyssim, Syssim, Chaush, Bobrovka and tributaries.
Isa district: Sveltoi-Bor and Veressovg-Uval rivers; Isa and Tura rivers and their tributaries.
Kamennushky district: rivers Bolshaya and Malaya Kamenushka, Kumenka, Niasma, and tributaries.
Kosvinsky district: Sosnovsky-Uval; rivers Bolshaya and Malaya Sosnovska, Loginskaya, Tilai, Malaya and Bolshaya Koswa, Kammenoye-Kovinsky, Kitlim and its sources; River Lobva.
Kanjakovsky district: rivers Jov, Poludnievaya, Bolshaya Kanjovska.
Gladkaja-Sopka district: rivers Travianka and its sources, Daneskine-Kamen, rivers Bolshaya and Malaya Solva; Talaya and Suprèiya, Soeva.
Gussevi-Kamen district: rivers Bolshaya Gussevka, Malaya Gussevka, Mokraya, Vyja and their affluents.
Simaya Gora district: in the Baramchinskaya-dacha: rivers Chumika, Nojovka, Bielnitshka. Deposits on right bank of the Barancha River, and the rivers Peschanka, Orulikha, Sukhoilog. Deposits of Kièdrovka in the Tagilskaya-dacha.
Pyroxenite deposits:
Deposits near Lake Chernoistotshnik, on the Tagilskaya-dacha. Rivers Oblèiskaya and Jegorovka Kamenka; also the Bolshaya Beresovska, the Bielogorska, and the small affluents of the east shore of Lake Chernoistotshnik. Deposits of the mountain chain of Kolpak-Karsansky. River Volkush.
Outside of dunites and pyroxenites:
Krebat = Salatim district.
Turinskaya-dacha in region of serpentines.
Tagilskaya-dacha, in eastern zone of the basic rocks.
Utkinskaya-dacha, south of Bisserk.
Chaitanskaya-dacha.
Neighborhood of Miass.
Ireland:
Wicklow, in some streams.
France:
Department Morbihan (Bretagne) at Penestin.
Cevennes, in alluvials of the Cèse River.
Chapeau Mountain near Chastelard, commune of Champoléon, in the Drac valley. Also, at St. Avay, Department Isère; at Montagnes des Rousses in Oisons, and on the right bank of the Bens, Savoy.
Germany:
In gold sands of the Rhine.
Palladium, or allopalladium, at Tilkerode in the Hartz Mountains.
Transylvania, near Freiberg.
Spain:
Deposits in the Ronda Mountains, Province of Malaga.
In the western part of the Asturias.

UNITED STATES

New York:
Nugget found near Plattsburg, weighing 104.4 grams; 46 per cent. platinum.
North Carolina:
Rutherford County.
Brown Mountain, Burke County.
Burnsville, Yancy County.
California:
Placer mines in Butte County.
Snake River gravels.
Humboldt, Plumas, Sacramento, Stanislaus, Trinity and Yuba counties.
Trinity County, in Trinity River, about 4 miles below Juniata City.
Yuba Consolidated Gold Fields, Hammonton, from gold diggings on Yuba River about 12 miles east of Marysville, Yuba County.
Calaveras, Del Norte, Shasta, Siskiyou, Amador and El Dorado counties.
West Point mining district, Calaveras County, just south of Mokelume River.
American River, with irodosmine.
Point Oxford (Cape Blanco).
Cherokee gold washings, Butte County.

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Oregon:
Beach deposits in Curry County (black sands); also near Kerby, Josephine County.
Auriferous placer gravels of Baker and Grant counties.
In almost every mining district in southwestern Oregon, the Waldo district being the chief producer.
Powder River Gold Dredging Co., in the Sumpter district, eastern Oregon, Rogur River.
Nevada:
Boss mine, Clark County.
Great Eastern mine, 25 miles northeast of Maopa, Clark County.
Wyoming:
Rambler mine, Albany County.
Copper concentrates from near Holmes, Douglas County.
Colorado:
Roll Call Mining Co., near Villa Grove.
Washington:
Placer concentrates of the southern branch of Lewis River.
Alaska:
Salt Creek mine, Prince of Wales Island.
Ketchikan mining district.
Koyuk, Fairhaven and Chistochina districts, Dime Creek, and the not far distant Bear Creek and Sweepstakes Creek.
Boob Creek, in the Tolstoi district, lower Yukon, Seward Peninsula.
Copper River country.
Red Mountain, on Kenai Peninsula.
Gum and Nome group of claims on south fork of Kaslo River.

CANADA

Quebec:
Rivière du Loup, Rivière des Plantes, Beauce County.
Newfoundland:
In chromite from serpentinised area of Mt. Cormack.
Nova Scotia:
In gold districts of Halifax County. In tungsten concentrates of the Moore River mines.
Ontario:
Sudbury copper-nickel mines.
Quinon claims, Munro township.
Manitoba:
At Le Pas, in shaft sunk by the Northern Manitoba Mining and Development Co.; also McCafferty's in the same neighborhood.
Alberta:
North Saskatchewan River, near Edmonston.
Yukon Territory:
In most of the tributaries of the Yukon River (with gold), notably at the mouth of the Hootalinque River, and in the Lewis River.
British Columbia:
Tulameen River and its tributaries, the principal one being Slate Creek; others are Cedar, Eagle, Bear and Granite creeks.
Franklin Camp, near Grand Forks.
Burnt Basin, Grand Forks mining district, south division.
Union mine, Grand Forks division.
Fraser River, below Lillooet.
Mother Lode claim.
Tranquille River.
Kamloops Lake.
Red Creek, tributary of Kettle River.
Ainsworth mining district.
Rock Creek, Yale district.
Queen Charlotte mining division, northeastern district; beach claim east and west of Rose Spit.
Fortuna group of mines, near Lewis Creek.
Rock Creek, Yale district.
North Thompson and Clearwaters rivers.
Granite Poorman Mining Co.'s property, a few miles from Nelson.
Siwash Creek in Tulameen district.
Consolidated Caribo hydraulic mine at Quesnal.

SOUTH AMERICA

Colombia:
In the rivers Atrato, San Juan, Condoto, Irro, Opogodó, Tamana, Sipi and Cajon. Also the Rio Chocó and at Santa Rosa de Osos, Antiquía.
French Guiana:
Alcoupi on the Approuague River.
Honduras:
Choleteca and Gracios.
St. Domingo:
Rio Yaqui.
Brazil:
Serra de Espinaco, from Itambo do Matto Dentro up to Itambo do Serro.
Bruscas, near Pernambuco.
In itabarites of Gondo Secco.
Corrego das Lagens, Minas Geraes.
In quarts veins in Parahyba Province, also in Boa Esperanca veins.
Corrego de Ouro Branco, Corrego di Tijucal, and Corrego dos Atoleiros. Also in Rio Abatêe washings.
Chile:
Beach deposits on island of Chiloe, off the Chilean coast.

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AUSTRALIA

New South Wales:
In gold deposits on northern beaches of the Evans River; in the Fifield gold fields ,and in the Parks district. Also Mulga Spring Creek, near Broken Hill, in a copper-nickel gossam, resembling deposits at Sudbury, Ont., Canada.
Victoria:
Thomson River copper mines.
Walhalla copper mine.
Queensland:
Beach sands between Southport and Currumbin, on southern coast.
Coopooroo and Wairamba creeks in the Russell gold field, near Innisfail.
Alluvial deposits in Brickfield Gully, and the Lady Mary and Ahmed reefs in the Gympie gold fields.
Head of Don River in central Queensland, about 30 miles from Mt. Morgan.
Tasmania:
Osmiridium in Savage River. Placers of Salisbury, near Beaconsfield. Wilson River.
Hazelwood Hills in the Waratah district, in serpentine.
New Zealand:
Thomas River in Westland, South Island; also near the Teremaku River, Tayaaka River, George River.
New Caledonia:
Alluvials of Audam Creek, near Boudé.

Occurrence in Quartz Veins.—Although the occurrence of platinum in quartz veins is not common, still several instances of this have been reported, as for example in a narrow gold-silver vein in the West Point mining district of Calaveras County, California, just south of the Mokelumne River. Here the country rock is granodiorite cut by greenstone dikes, and in the numerous quartz veins gold is a valuable constituent, generally in association with a considerable amount of pyrrhotite and lesser amounts of pyrite and chalcopyrite. This is the case with the Keltz group of claims, located to the northeast of the village of West Point, where in 1920 a quartz vein was opened to the depth of about 40 ft. From this shaft were sent small shipments of ore, averaging about $156 per ton in gold and silver. One of these lots contained 0.11 oz. per ton of platinum. Mr. Henry W. Turner states that there is no serpentine or peridotite or other ultra-basic igneous rock near the shaft.[1] However, it is not unlikely that the platinum was originally contained in an intrusion of peridotite, which has gradually weathered away.

Platinum in quartz veins has also been reported by Prof. C. F. Hartt in his "Geology and Physical Geography of Brazil," p. 448, where he cites E. Williamson as recording the occurrence of platinum in such veins in Parahyba Province. Here the country rock is of schists and gneisses, presumably of pre-Cambrian age, with lenticular veins of a semi-opaque white quartz, which generally lie parallel to the strike of the enclosing schistose series. Native gold, with sulphides and arsenides of iron and sulphides of copper, lead, and zinc, occur commonly in these veins, but in addition to these constituents, grains of platinum have been found in the Boa Esperança veins.[2]

There are instances of such occurrence in North America, for in 1904 Brock[3] reported the presence of platinum in a quartz vein furnishing

[1] Henry W. Turner, "Platinum in Quarts Veins," *Eng. Min. Jour.*, Mar. 25, 1922.
[2] *Op. cit.*
[3] *Eng. Min. Jour.*, Feb. 18, 1904.

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about $3 worth of gold per ton of ore, at Burnt Basin, three miles west of Coryell, in the Grand Forks mining division, Yale district, British Columbia. The mother lode was in a greenstone formation between two porphyry dikes, and it contained pyrite, chalcopyrite, galena, and sphalerite, with a little molybdenite. The platinum content was shown by assays to be from 0.06 to 0.1 oz. per ton of ore. Another Canadian instance is reported by O'Neill, in his paper on "Platinum in Canada,"[1] where he writes of an occurrence of platinum in a quartz vein traversing granodiorite in the Ainsworth mining division, British Columbia, and also in the Union mine, in the Grand Forks division of the same province, where the metal appears associated with lead, gold and silver.

A similar occurrence is noted in 1905, by Bell, in quartz veins on the South Island of New Zealand,[2] near the Teremaku River, district of Westland. Here the quartz veins are in close proximity to sheets of altered magnesian eruptures, which appear to have been dunites and are parallel to the stratification of the enclosing phyllites. By analysis, platinum was found to be present with silver, the respective quantities per ton of ore being: platinum, 0.167 oz.; silver, 1.22 oz. Analysis of the magnesian eruptives failed to disclose any platinum content. Finally, platinum appears in gold-quartz veins of the Beresevsk district, Ural Mountains, and also in northern Finland. In all these instances, it is far from unlikely that the original intrusive mother-rock of the platinum has decomposed and disappeared, leaving the hard metal behind in the quartz vein.

TECHNOLOGY

In the report last year[3] mention was made of the making of extremely fine platinum wire. At the request of the present writer several lengths of such wire were produced by Baker & Co. of Newark, N. J., and results were obtained far surpassing those described last year. In this method it is necessary to cover the platinum core with a thin silver coating; when the wire had been drawn out, the coating was removed, leaving a platinum wire one hundred-thousandth of an inch in diameter. Careful computation shows that one gram of platinum would furnish a wire of this dimension 351.42 miles long, and from one troy ounce of the metal, a wire 10,929 miles long, approaching half the circumference of the earth at the equator, could be produced. Hence from 2.5 oz. of the metal could be made a wire that would girdle the earth at the equator and leave 2400 miles to spare.

Some excellent information as to the best methods for separating platinum from the black-sand deposits have been recently published in the

[1] Summary Report, 1918, Part G., Geol. Surv. of Canada, p. 8G.
[2] James Mackentosh Bell, *Econ. Geol.*, 1, 749 (1905).
[3] MINERAL INDUSTRY, 29, 561 (1920).

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Engineering and Mining Journal.[1] One method, pursued at Oroville, Calif., is to use the trough-shaped gold-washing device called the "long tom" to secure the requisite concentrate. This device is 1 ft. wide and 12 ft. long, and has a grade of 1 in. to the foot. The concentrate so obtained is taken to the clean-up room, when the bulk of the amalgam is separated and retorted. The black sand containing platinum, and a small amount of amalgam and rusty gold, is washed several times in a miniature "long tom," the bulk being reduced to about one pint in which are gathered the gold and the metals of the platinum group. The surplus mercury is now drawn off and the concentrate is poured back and forth between two crockery bowls so as to remove almost all of the black sand. The residue is treated with concentrated nitric acid to remove any base metal and to brighten the rusty gold so that it will amalgamate. Finally, the platinum can be cleaned by using magnet and blower. As the platinum of the Oroville district occurs as flakes or grains, Logan does not believe that the best possible results are attained by panning and the "long toms," but the quantity is so small that the expense resulting from more careful work would scarcely be justified.

The Yuba Consolidated Goldfields treat the material in a different way. From the working of each dredge about 3 tons of concentrate is secured in a week, and from 60 to 70 tons of material is treated every month. Each dredge has a "long tom," and the sand is ground in a steel ball-mill with a weak cyanide solution to brighten the rusty gold. Then the slime is discharged into a well whence it is pumped into a small settling tank and treated with cyanide. The ball-mill is provided with a string of sluices 40 ft. long and 1 ft. wide, with a grade of 1 in. to the foot. They have a mercury trap, 2 ft. of silverized amalgamating plate, 3 ft. of iron cross-riffles, 5 ft. of cocoa matting and 8 ft. of wooden riffles loaded with mercury; the balance of the sluice is covered with cocoa matting beneath expanded metal. The slime having been drawn off the mill is opened so that the sand discharges into the sluice. As a result $40 per ton of gold and platinum is secured, the gold extraction being nearly perfect; no definite figures are given of the platinum output. There is no report of the employment of dry concentration in any of the mines, of oil-flotation, or of the Wilfley tables. Where pan-motion of bateas is used it has been found to be much easier to secure the platinum from sand of its own screen size than from sand of all sizes.

In the Bureau of Standards a new method for the analysis of platinum has been carefully tried out. A chief objection to the methods heretofore pursued lies in dividing the ore into two fractions by the use of aqua regia. This can be avoided by first fusing the ore with

[1] Feb. 11, 1922, p. 251, citing Logan, "Platinum and Allied Metals in California."

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zinc, disintegrating the zinc obtained with hydrochloric acid, and then fusing the residue with potassium pyrosulphate; by this latter means the iron is removed, but it was also found that all the rhodium in the ore was taken up as well as the copper, and probably the silver also. Experiments on pure iridium showed that the loss of this metal caused by the fusions was negligible. Like experiments are being conducted with platinum and osmium, and the effect on palladium will also be studied. This method will be entirely different from the one now employed and it is believed in the Bureau that it is much more accurate and at least as rapid as those now in use.

A careful investigation by the Bureau of Standards revealed the fact that certain platinum-rhodium thermocouples, imported from Great Britain, exhibited considerable changes in their indications after exposure to high temperatures. The cause of this was shown by chemical and spectroscopic tests to be the presence of several tenths of a per cent. of iron in the platinum-rhodium alloy. When the matter was brought to the notice of the British manufacturers they took up the problem of eliminating the iron, and tests lately made by the Bureau of Standards shows that the new couples are entirely satisfactory, as were those made in America which had also been tested by the Bureau.[1]

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POTASH

By Frederick W. Brown

The general situation, so far as American production of potash in 1921 was concerned, was one of almost complete stagnation. Most of our plants were closed at the beginning of the year owing to total failure of the market. By May all primary plants had ceased operations and several had heavy stocks on hand. Two cement mills continued to collect dust throughout the year and two alcohol distilleries produced potash char from their residues, but with these exceptions the industry was prostrate.

This situation was brought about by heavy importations of European potash free of duty, and simultaneously the failure of our farmers in the spring of 1921 to purchase, on the average, more than half their normal requirements of fertilizer. Hope that anticipation of better spring business in 1922 would lead the fertilizer manufacturers to buy American potash in the fall of 1921 was dissipated when the leading fertilizer companies combined to sign a contract with the German Syndicate for three-fourths of their spring requirements at prices below the American costs of production. A similar contract with the French producers for an amount estimated to cover the remaining 25 per cent. of the requirements, at prices identical with the German figures, made it impossible for the American companies to enter the market.

The general tariff bill as passed by the House of Representatives in the fall carried a provision levying a duty for five years after the passage of the bill on crude potash salts. This duty was to be 2½ cts. per lb. of K_2O contained in the salts for the first two years after the passage of the bill; 2 cts. per lb. for the third year; 1½ cts. the fourth year; and 1 ct. the fifth year, after which potash should again be free. It is the confident belief of the American producers that this temporary and diminishing duty is all that is necessary to put the industry on its feet and in a position to contest the German monopoly of the business. No relief was afforded by the bill, however, as delay in its consideration by the Senate extended through the year.

American Production and Sales

Figures issued by the United States Geological Survey show a production from American plants in 1921 of 25,485 short tons of potash salts, equivalent to 10,171 tons of actual potash. This was produced by eighteen companies, operating twenty plants As will be seen in the following table, this is the lowest production since 1915:

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TABLE I.—POTASH PRODUCED IN THE UNITED STATES, 1915–1921

Year.	Number of Producers.		Production.		
	Total.	Exclusive of Wood-ash Producers.	Crude Potash (Short Tons).	Available Content of Potash (K_2O) (Short Tons).	Average K_2O Percentage in Crude Salts.
1915	5	5	4,374	1,090	24.9
1916	70	25	35,739	9,720	27.2
1917	95	46	126,961	32,573	25.6
1918	128	77	207,686	54,803	26.4
1919	77	45	119,736	32,418	27.0
1920	53	34	184,066	49,232	26.7
1921	20	19	25,485	10,171	40.0

The table also brings out the fact that the potash produced in 1921 was of much higher average grade than in any previous year. This is undoubtedly due to the fact that the production of Nebraska potash, which carries from 20 to 25 per cent. K_2O, was very limited in 1921, whereas in previous years it constituted nearly half the total output, while there was a relatively heavy production in 1921 of high-grade muriate from Searles Lake.

TABLE II.—DOMESTIC POTASH SOLD IN THE UNITED STATES IN 1921, CLASSIFIED ACCORDING TO MATERIAL MARKETED

Material Marketed.	Crude Potash (Short Tons).	Available Content of K_2O.		
		Per Cent.	Short Tons.	Percentage of Total.
Crude mixed salts	4,432	25–42	1,517	34.4
High-grade chloride	5,028	50–58.7	2,741	62.2
Dust from cement mills and blast-furnaces	657	1.8–11.2	52	1.2
All other (a)	220	29–51	98	2.2
	10,337	.....	4,408	100.0

(a) Includes sulphate, low-grade chloride, and crude caustic.

Texas Potash Deposits

What may prove to be very important discoveries of potash beds have come to light in the last year or two in west Texas. In boring for oil, salts comparable in richness with the German deposits have been encountered at a number of widely separated places. As in the case of the European beds, these Texas deposits are in conjunction with rock salt and the potash material is in the form of polyhalite, one of the characteristic German potash minerals.

The U. S. Geological Survey has been watching the situation for some time in coöperation with the University of Texas. Analysis of the material brought up by the drill has been made in each instance and has established the fact that potash salts do occur in Texas similar to the celebrated German deposits. Unfortunately, it is impossible from the

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data in hand to determine the thickness of the potash-bearing stratum or strata, and this can be determined only by the use of a core-drill.

However, as the indications have been found over a region 300 miles in extent, it is almost incredible that somewhere in the area the potash should not be found in a stratum thick enough to warrant commercial exploitation. Efforts are being made at present by several companies to explore the most likely points in this area with core-drills, which will give a trustworthy picture of the underlying strata. If commercial deposits are located it will prove of the first importance to the industry.

Imports

The same causes which restricted American production of potash also operated to reduce importations. A fully stocked or even over-stocked market, combined with a sharp reduction in the demand for fertilizer, brought the total importations down to 250,245 short tons of salts, equivalent to 81,017 tons of K_2O, as compared with 982,262 tons of salts and 224,792 tons of K_2O in 1920.

The following table shows the imports of the more important potash salts for the years 1919–1921 inclusive, together with the declared values:

TABLE III.—IMPORTS OF POTASSIUM SALTS
(In tons of 2000 lbs.)

	1919.		1920.		1921.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Kainit	57,427	$921,481	416,661	$8,212,621	77,365	$1,453,854
Manure salts	45,372	1,269,750	348,837	10,625,717	43,286	792,601
Muriate	23,202	1,783,916	136,195	12,703,858	79,642	4,777,726
Sulphate	1,415	188,592	17,006	2,343,431	12,459	719,183
Bicarbonate	24	8,921	194	93,565	197	33,352
Bitartrate (argol)	12,904	4,311,610	17,726	4,452,428	8,089	1,189,902
Bitartrate (cream of tartar)	12	10,879	109	83,903	668	306,674
Carbonate, crude	258	104,744	8,452	510,700	2,024	191,265
Carbonate, crude black salts	102	10,075	7,356	417,797	1,664	76,091
Carbonate, refined	23	9,665	882	290,354	70	14,952
Caustic	242	134,166	856	451,274	5,455	487,183
Chlorate	100	34,996	742	162,417	2,771	246,191
Chromate and bichromate	8	4,271	2	2,690	37	6,772
Cyanide	588	68,848	7,224	1,088,247	1,886	319,683
Ferricyanide (red prussiate)	17	18,096	51	64,686	13	4,878
Ferrocyanide (yellow prussiate)	258	122,372	381	105,962	224	91,447
Iodide	9	54,250	3	14,872	*Nil.*	*Nil.*
Nitrate (saltpeter), crude	18,826	1,107,313	18,816	1,599,346	8,297	590,200
Nitrate (saltpeter), refined	37	8,171	631	107,154	5,710	45,548
Permanganate	2	10,163	27	29,748	192	72,232
Rochelle salt	20	9,537	59	29,013	194	62,141

Potash in Foreign Countries

Germany.—The year witnessed a tendency for the potash industry in Germany to become consolidated in relatively a few strong hands. Combinations were formed within the Syndicate, the object being the reduction

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of costs through the acquisition of weak companies by strong ones, and the closing of the less important mines and works, thereby throwing the available business into the hands of the concerns best equipped to produce at a minimum cost. How far this policy was carried there are no records to show, but that many of the less advantageously located and less adequately equipped works did not operate is certain.

Even with the business thus concentrated where it could be handled most cheaply, the steadily rising scale of commodity and labor prices in Germany has forced repeated raises in the internal price of potash, and will undoubtedly continue to do so until an economic adjustment has been accomplished.

The continued fall of the mark in dollar exchange operated throughout the year to give German producers a great export advantage. It is true that German costs of production rise steadily as a result of the same forces which depress the mark, and German prices tend constantly toward the international price-level. Stabilization of the mark at any level, no matter how low, would soon be followed by corresponding stabilization of German internal prices at a level which would make their costs of production comparable with the costs in other countries. But since it takes time for labor to force its wages up, and railroads to raise transportation rates, and even a rise in commodity prices must await the termination of existing contracts, it follows that with the mark steadily dropping, there is a wide differential between the purchasing power of the mark in American exchange and its purchasing power in Germany. During 1921 the mark would buy from two to five times as much labor, transportation, or commodities in Germany as its equivalent in dollar exchange would buy in America.

As a result of this condition the German Potash Syndicate, despite the fact that it has raised its prices on internal sales time after time in recent months, was yet able to contract with American fertilizer men for a large tonnage of potash at practically the 1913 price.

The following tables show production and sales of German potash over a period of years:

TABLE IV.—PRODUCTION OF GERMAN POTASH SALTS
(In metric tons)

Year.	Production.	Year.	Production.
1911	9,706,507	1917	8,938,738
1912	11,070,014	1918	9,438,251
1913	11,607,510	1919	7,772,036
1914	8,171,512	1920	11,386,439
1915	6,897,476	1921	9,211,869
1916	8,642,887		

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TABLE V.—GERMAN POTASH SALTS
(In short tons of K_2O)

Year.	Domestic Sales, Tons.	Foreign Sales, Tons.	Total, Tons.
1911	527,822	441,941	969,763
1912	581,422	524,514	1,105,936
1913	664,711	556,695	1,221,406
1914	591,590	402,797	994,387
1915	623,807	123,947	747,754
1916	797,548	174,825	972,373
1917	958,625	146,084	1,104,709
1918	945,688	156,142	1,101,830
1919	700,735	192,466	893,201
1920	760,380	257,476	1,017,856

France.—While the producing capacity of the Alsatian potash mines and plants was increased during the year, the situation was complicated by the question of the ultimate disposal of the properties by the French Government. The decision finally reached, to retain the ownership and lease the properties to a company or companies to operate, was not put into effect during the year.

The production of the Alsace potash mines shows a marked decrease for 1921; the figures, as given by the Société Générale Alsacienne de Banque, are as follows, those for 1920 being shown between brackets: Crude salt, 895,744 metric tons (1,203,000 tons); pure potash (K_2O), 146,355 tons (192,480 tons).

The Société Commerciale des Potasses d'Alsace state that the demand has become more active, both in the home market and abroad.

New equipment and improved methods have been put in and the claim is made that these improvements, together with the fact that the crude Alsatian material averages 16.4 per cent. K_2O as against an average of 10.5 for the German crudes, make it possible for the French to meet German competition in the world markets.

Contracts were made in the fall by the French combine with fertilizer manufacturers in this country at prices identical with the German figures. Whether either French or Germans found the business profitable at this pre-war level is doubtful, and it is considered by many well-informed persons as almost inevitable that once the Alsatian mines are in the hands of private operating companies, some means will be found for eliminating competition between the French producers and the German Syndicate and fixing prices for export.

Poland.—Potash deposits of considerable importance exist in Polish Galicia. In the Kalusz district four beds occur, containing chloride and sulphate of potash and chloride and sulphate of magnesia. Sylvinite (25 per cent. potassium chloride) 2 meters in thickness occurs in the first bed, below which is a deposit of kainit from 10 to 12 meters in thickness.

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Some 30 meters below the kainit bed is a second layer of sylvinite carrying 12 per cent. potassium chloride; and still lower is found another deposit of sylvinite reported to be 42 per cent. potassium chloride.

These beds have been worked in a small way and the product disposed of locally. It is proposed to extend the operations and while it is doubtful whether the product of the district will ever affect foreign markets, there should be an excellent opening in Poland itself, since before the war the country was a large consumer of German potash.

Spain.—The deposits at Suria in Catalonia seem in a way to meet the Spanish requirements for potash in the near future. A large plant is in process of building with a producing capacity equal to the whole present Spanish consumption. A railroad to Manresa has been laid and the plans include an extension of this line to Barcelona. The Catalonian deposits are believed to contain many millions of tons of potash salts.

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PRECIOUS STONES

By George F. Kunz

The year 1921 has been a remarkable one for the precious-stone industry as compared with the preceding years. It has been marked by the shutting-down of the larger diamond mines and of nearly all the smaller sources. In ruby mining, fewer stones have been found, and this is also true of the semi-precious stones. Many of the lesser gems, such as the amethyst, agate, carnelian and amber, have been cut to a considerable extent by the Chinese, and to an even greater extent in the Rhine provinces, many young apprentices having been employed, and great quantities of material sent all over the world.

In the pursuance of their conservative policy, the directors of the great De Beers combination stringently curtailed production in the course of 1921, finally bringing it practically to a standstill. Nevertheless, the sales of diamonds for the year ending June 30, 1921, amounted to the respectable figure of £2,300,581; however, the latter half of 1921 did not make as good a showing. This action of the large producers necessarily forced the owners of the smaller mines to follow their example, more especially as they had no great reserves like the largest company, and in Southwest Africa similar measures were taken. When, however, the turn of the tide comes, everything is in readiness to take full advantage of it.

When we consider the unusual prosperity enjoyed by the precious-stone industry in 1919 and in the first half of 1920, the reaction evidenced in the present period of depression seems to be only a natural one, and the prospects for the future may be pronounced satisfactory. Undoubtedly the increased incomes resulting from the tremendous stimulation of many branches of business during the World War, and for some time thereafter, created a strong and widespread demand for precious stones, more particularly for diamonds. As the number of buyers grew, prices rapidly mounted, especially as the situation was very wisely handled by the great London Diamond Syndicate, which practically controlled the whole diamond output.

However, coincidentally with the falling-off in the number of purchasers, came the marketing, in one way or another, of a considerable quantity of old diamonds owned by exiled Russian aristocrats and also by noble families of many other European countries where the old order of things had been overthrown. This has created a temporary compe-

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tition with the mine products even though the actual production has been very greatly decreased. Still, this marketing of old diamonds will very soon cease, and with the hoped-for return of economic stability throughout the world, the precious-stone industry will resume an upward movement.

Besides the sale of jewels by the impoverished nobility of certain European countries, another unfavorable competition with the marketing of new diamonds from the mines arose from the generous and thoroughly justifiable policy of some leading gem dealers in the United States to take back from many of their customers diamonds which had been bought in the recent era of greatest prosperity. This has often been done under similar circumstances in the past, and aside from the accommodation afforded to individuals, it greatly serves to stabilize the market in a temporary period of depression.

United States Imports

For the United States, and therefore to a considerable extent for the whole world, the record of precious-stone imports into this country constitutes a barometer recording the varying prosperity of this branch of industry. As a fair instance of the striking differences from one year to another, we give the figures of these imports for the ten-year period 1911–1920:

1911	$42,315,830	1917	$40,906,667
1912	42,552,720	1918	24,272,000
1913	46,560,608	1919	105,273,543
1914	19,764,987	1920	75,855,591
1915	26,521,330		
1916	51,590,080		$475,613,356

This gives an average per year of $47,561,133. The imports for 1921 amounted to $38,127,649, and although this total falls far below that of the record years 1919 and 1920, it is larger than the average for the eight years 1911–1918, which was $36,800,000. This serves to emphasize the essential stability of the diamond market, in spite of notable fluctuations.

IMPORTS OF DIAMONDS AND OTHER PRECIOUS STONES INTO THE UNITED STATES

	1918.	1919.	1920.	1921.
Diamonds, glaziers' and engravers', unset and miners', free	$718,397	$984,381	$1,527,753	$435,872
Diamonds, uncut, dutiable	12,605,526	20,315,758	10,527,363	2,257,299
Diamonds, cut but not set, dutiable	7,761,810	64,222,947	45,444,999	26,338,455
Pearls and parts of, not strung or set, dutiable	722,981	11,541,000	7,377,772	4,538,803
Other precious stones and bort, dutiable	604,550	1,623,522	3,717,741	733,919
Other precious and semi-precious stones, cut, but not set, dutiable	968,094	5,006,032	5,031,639	2,587,404
Imitation precious stones, dutiable	890,642	1,579,903	2,228,325	1,235,897
	$24,272,000	$105,273,543	$75,855,591	$38,127,649

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IMPORTS OF CUT DIAMONDS AND PEARLS ACCORDING TO THE SOURCE

	Diamonds, cut, but not set, dut.			Pearls, and parts of, not strung, not set, dut.		
	1919.	1920.	1921.	1919.	1920.	1921.
Imported from:						
Belgium			$12,024,417			
France	$2,033,268	$2,506,090	638,443	$5,982,654	$3,861,617	$3,543,425
Netherlands	53,561,019	31,024,241	11,497,228			
United Kingdom	6,664,911	3,003,534	1,873,039	5,347,460	3,235,320	802,949
British India				81,003	79,452	48,637
Other countries (a)	1,963,749	8,911,134	305,328	129,883	201,383	143,792
Totals	$64,222,947	$45,444,999	$26,338,455	$11,541,000	$7,377,772	$4,538,803

(a) Includes cut diamonds from Belgium before 1921.

Prima facie, there does not seem any reason to identify the cut diamonds entered at New York from "other countries" with the so-called "Russian" diamonds sold by exiles or looters. In 1919 and 1920 no reports are made for Belgium, but the $8,911,134 for other countries in 1920 (nearly five times as much as in 1919) evidently refers to the newly awakened Antwerp industry, for while this in 1921 is $12,024,417, "other countries" have then fallen off to only $305,328.

From 1867 to 1917, the total value of imports of "diamonds and other precious stones" was $771,544,558. As in many of the earlier years no distinction was made between diamonds and other precious stones a small allowance has to be made for the latter, but it can safely be assumed that the diamonds were worth close to $750,000,000. Since 1917 we have nearly $200,000,000 additional for diamond imports. This gives us a total not far short of a billion dollars, and the cost of acquisition to the present owners, embracing as it must the duties, the sales tax, the cost of cutting the uncut diamonds, the setting, and the profits of the eventual sellers, may be set at twice as much or more.

Diamonds

Many conditions conspired to make diamond mining different from what it has ever been before, and resulted in an extensive closing-down of the principal mines. Much discussion has been indulged in as to the precise causes which determined the large purchases of diamonds made just before and during the war by Germans and Russians, and it has been shrewdly surmised that the ulterior aim was to stabilize the financial status of these countries and of individual buyers, for diamonds offered a permanent security for investments against the inevitable breakdown of the currency. When this finally occurred, the greater part of the accumulated diamonds were thrown upon the market in 1921 by the

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German and the Russian owners, and nothing has more clearly proved that the stones were not bought to be cut and set into jewels than the fact that in many instances a number of packages still bearing the original, unbroken seal, and each containing diamonds worth £100,000 each, were among the goods thus offered for resale at a lower than purchase price.

Thus the Diamond Syndicate has had manifold difficulties to contend with in its efforts to maintain diamond prices. The writer of the present article in an address at Chicago, before the Economic Section of the American Association for the Advancement of Science on Dec. 27, 1920, drew attention to the superior excellence of diamonds and precious stones as the only stable portable investments for war or revolution, and was able to give many historical proofs of the truth of this contention.

The depression in the diamond industry was strikingly shown in the heavy decrease of sales in 1921 as compared with 1920, according to the reports of the Department of Mines and Industries of the Union of South Africa. As shown in the table below there was a drop of more than £8,000,000. The value per carat also declined, although not quite so sharply. Moreover, the Customs statistics show exports of only 316,702 carats, worth £1,355,487 in 1921, while in 1920, 2,039,544 carats were exported at a value of £11,597,451. As during the 5-year period 1916–1920 the weight of the diamonds produced exceeded the weight of the diamonds sold by 1,254,328 carats, the export returns for 1921 prove that we must add 213,404 carats to this total to figure the quantity of the 6 years' output still held by the Diamond Syndicate. This gives 1,467,-733 carats.[1]

The total sales since 1913 are given as follows, a part of the diamonds sold having been mined in previous years.

	Carats.	Value.	Value per Carat.
1913	5,537,820	£12,088,983	43s. 8d.
1914	3,363,568	6,758,544	40s. 2d.
1915	551,951	1,459,597	52s. 11d.
1916	2,291,956	5,227,777	45s. 7d.
1917	2,416,209	6,170,906	51s. 1d.
1918	2,641,932	7,232,744	54s. 9d.
1919	2,648,931	13,379,662	101s. 0d.
1920	1,765,554	10,163,941	115s. 2d.
1921	530,107	2,161,796	81s. 7d.

Diamond-cutting and Trade

The pioneer in building up a considerable diamond-cutting industry in England, Sir Bernard Oppenheimer, Bart., died at his country residence, Sefton Park, near Slough, on June 13, 1921, at the age of fifty-four years.

[1] *So. Afr. Min. Eng. Jour.*, Mar. 25, 1922.

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He owed his great reputation and his title to his important efforts to help win the World War. In conjunction with a few partners he built an immense factory at Letchworth for the manufacture of war munitions, and by 1916 its output was not less than 16,000 shells per diem. A similar energy, though enlisted in a less important cause, marked his building up of a diamond-cutting industry in which maimed or otherwise disabled veterans could receive training in this delicate and well-remunerated vocation. As illustrating the relative success of this enterprise, we may note that while the value of the cut diamonds imported from the United Kingdom into the United States for the year 1921, was $1,873,039 as compared with $3,003,534 for 1920, the percentage which this represented of the total diamond imports was 7.11 in 1921 against 6.61 in 1920. This seems to show that the English experiment is at least moderately successful.

France has followed the example of Great Britain in starting a diamond-cutting establishment where disabled soldiers will receive training in this work. It is situated in Versailles and was initiated at the instance of Joseph Asscher, senior member of the great diamond-cutting firm of Asscher Bros. in Amsterdam. For his activity in behalf of the French veterans he has been awarded a decoration of the Legion of Honor.

As to the activity of the French Diamond Commission, the President of the Chambre Syndicale des Diamants, Perles, Pierres Précieuses et des Lapidaires, made the following statement at the meeting of Jan. 11, 1922:

> The activities of the Commission shall be as follows:
>
> *Importations.*—As in the past, authorizations by the President, control of the arrival at the custom house by the commissioners.
>
> *Exportations.*—Control by the Commission and at the Chambre Syndicale, in presence of a customs representative; the sealed note of the exporter, provided also with the sealed note of the Commission, is addressed to the nearest post office.
>
> It should either be accompanied by an agent of the Post Office, or controlled by means of a memorandum stamped at the Post Office, if there shall be an agreement between the Postmaster General and the Minister of Finance.
>
> The control of exportation shall be available for the service of indirect contributions (business returns).
>
> The Commission should give its opinion in case of litigation.

Concerning the diamonds sold by Russians in the Antwerp market in 1921, the following details transmitted to the U. S. Department of Commerce by James T. Kirby, clerk in the American Consulate at Antwerp, under date of July 26, 1921, are of importance:

"For a period of about two months the supply of diamonds from

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Russia had apparently ceased, when suddenly a lot of several thousand carats was again negotiated on the market. A considerable portion of this lot must, of course, be recut. Besides these Russian stocks, the importance of which has been somewhat overestimated, the market seems to have been further unfavorably influenced by contraband and smuggling, which had been on the increase since the signing of the armistice.

"It is thought by some merchants that the Government could intervene to advantage by placing on stones presented for recutting a real duty, say 20 per cent. Such a measure, however, besides being very difficult of application, would be inoperative unless adopted by all countries. The measure taken in one country only would result in favoring cutting establishments in neighboring countries. Antwerp would then remain exposed to the disagreeable duty of smuggling so long as the situation did not improve in Russia and Poland, where persons in need of funds sell their jewels at low prices. At present, therefore, it is difficult to give a carat a value which would be approximately exact.

"The London Syndicate recently began to buy Russian diamonds, which has done much toward eliminating the bad influence of this dumping."

Diamond Mining and Production

Congo.—In the Congo, the diamond resources have been actively developed in recent years, as is shown by the following statistics of production:

DIAMOND OUTPUT OF THE BELGIAN CONGO

	Carats.		Carats.
1915	48,995	1919	275,000
1916	53,940	1920	315,000
1917	100,000	1921	174,000
1918	164,420		

A considerable number of what are known as "industrial diamonds," chiefly for use in diamond drills, are brought to Antwerp from the Congo, and toward the end of 1921 two of the principal London dealers in this class of diamonds agreed with the Congo Diamond Regie at Antwerp to buy all of the next three consignments of these diamonds from the Congo up to a maximum of 70,000 carats each time.

Southwest Africa.—Operating under the terms presented by the conference of the four large South African diamond producers, held toward the close of 1919, the Consolidated Mines of Southwest Africa, the new organization which has taken over the properties of the old German companies in Southwest Africa, was assigned the following quotas of output for the four quarters of 1920 at the given base prices

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per carat.[1] In order to show the number of carats, we have divided the quotas by the base price in each case.

	Quota.	Base Price.			Equivalent in Carats.
		£.	s.	d.	
First quarter	£619,580	5	12	4	110,344
Second quarter	630,000	7	4	7	87,200
Third quarter	540,330	8	4	4	65,770
Fourth quarter	275,583	8	9	5	32,517
	£2,065,493				295,831

The cost of operation varied considerably. For 1920 it was about £1 4s. per carat; but it was lower than it would have been but for the fact that the scale of operating was above normal requirements. The Government pays 70 per cent. of these working costs, as a partial offset to its heavy tax on the value of the diamonds exported.

The Anglo-American Corporation of South Africa, Ltd., which has acquired a very large interest in the Consolidated Diamond Mines of Southwest Africa, Ltd., has deposited with the Guaranty Trust Co. of New York a certain number of its £1 shares, and the Trust Co. is issuing "American shares" of no par value, each of which represents five of the £1 shares. The Anglo-American Corporation has also considerable holdings in several gold-mining companies, and in the Transvaal Coal Corporation, Ltd. Its interest in the Consolidated Diamond Mines of Southwest Africa is principally constituted by its holdings of the company's 8-per cent. debentures, secured by a mortgage on the mining property, which, as has already been stated in these reports, consists of the diamantiferous area formerly owned by the German companies of Southwest Africa. The Anglo-American Corporation paid two 5-per cent. dividends on its shares in 1920, and one such dividend in 1921, but although the earnings permitted another 5-per cent. dividend in 1921, it was thought wiser, in view of the temporary depression of the diamond market, to conserve the company's resources.

The diamond output is sold through the London Diamond Syndicate subject to the arrangement that the share of the various interests shall be as follows: 21 per cent. for the Consolidated of Southwest Africa, 51 per cent. for the De Beers mines; 18 per cent. for the Premier mine, and 10 per cent. for the New Jagersfontein mine. Quite recently it has been stated that the Anglo-American Corporation has bought some 8,000,000 francs' worth of Congo diamonds, which will also be disposed of

[1] *Eng. Min. Jour.*, Oct. 29, 1921.

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by the London Syndicate. This would tend to remove any competition of Antwerp with London in the diamond trade.

Union of South Africa.—While usually the largest diamond producer in South Africa is Cape Province, in 1921 more diamonds were recovered in the Transvaal. Of a total of 424,486 carats worth £1,254,151, the Pretoria district furnished 358,505 carats valued at £852,949, this representing practically the output of the Premier mine. Kimberley, Cape Province, furnished 179,752 carats, and Barkley West 53,725 carats. From the Orange Free State, the great alluvial diamond field, came 143,686 carats. The depression has been most accentuated in Cape Province, where are the De Beers mines, although operations were on a reduced scale in the Transvaal also. The somewhat better results realized here are due in great part to the different way in which the mining is carried on, for in the Premier mine the diamonds are rather quarried than mined, so that the expensive white labor is less necessary than it is at Kimberley, where the work is largely performed at fairly great depths. On the other hand, the region least affected by labor conditions has been the Orange Free State, where individual prospectors secure the stones from the alluvial diggings.[1]

The alluvial diamond output of Cape and Transvaal provinces for 1921 was as follows:

	Carats.	Value.
Cape Province	59,811¾	£420,297 11s. 3d.
Transvaal Province	79,636	£422,508 1s. 6d.

This gives a value per carat of £7 0.54s. for the Cape Province stones, and of £5 6.11s. for the Transvaal stones.[2]

PRODUCTION OF DIAMONDS IN SOUTH AFRICA

Year.	Production from Mines.			Alluvial Diamonds.		
	Carats.	Estimated Value.	Value per Carat.	Carats.	Estimated Value.	Value per Carat.
1913	4,944,946	£10,254,203	41s. 6d.	206,049	£1,120,227	108s. 9d.
1914	2,653,089	4,906,342	37s. 0d.	143,924	576,729	80s. 2d.
1915	2,131	3,887	36s. 6d.	97,678	392,196	80s. 4d.
1916	2,170,348	4,769,479	43s. 11d.	167,620	948,571	113s. 2d.
1917	2,710,041	6,659,721	49s. 2d.	182,992	1,041,776	113s. 10d.
1918	2,385,361	6,137,283	51s. 5d.	143,438	964,574	134s. 6d.
1919	2,366,744	8,960,614	75s. 9d.	209,589	2,740,548	261s. 6d.
1920	2,312,436	12,289,602	106s. 3d.	221,460	2,441,440	220s. 6d.
1921	424,486	1,254,151	59s. 2d.	283,134	.....	.....

The depression of the diamond industry, which must continue until the great stock of diamonds thrown on the market by the Russian Government, and the accumulations of South African diamonds held by the London Syndicate, have been absorbed by the buyers, has induced

[1] *So. Afr. Min. Eng. Jour.*, Mar. 25, 1922.
[2] Communicated by Mr. E. Gibbs, of the Detective Service of South Africa.

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the closing-down of most of the diamond mines in South Africa. However, the Premier company has continued operations, though on a reduced scale, work being confined to five 8-hr. shifts per week, some 5000 loads of blue ground being worked on each shift in the No. 3 gear.

In addition to this information, we are indebted to Dr. Percy A. Wagner[1] for the following description of an improvement in the treatment of the blue ground that has recently been introduced at the Premier mine:

"Dressing operations at this mine have been greatly simplified within the past two years by doing away with the jigs formerly employed for re-treating the concentrate made by the working gears. The concentrate is conveyed by means of a belt to three tube-mills run at such a speed as to ensure that crushing is performed by attrition without impact. These discharge into revolving screens with round holes 1/16 in. in diameter, everything below this diameter being rejected. The oversize is elevated to trommels with square holes of 5/8 in. and 1/2 in., and round holes of 3/8 in. and 1/4 in. These give six products, each of which goes to a greased Frue vanner. The concentrate collected on them is automatically scraped off and freed of the adhering grease in electrically heated melters fixed to the vanner frames. The product thus obtained represents 1/250,000 part by weight of the blue ground sent to the washing plant."

DIAMOND OUTPUT OF PREMIER MINE

Year Ended Oct. 31.	No. of Loads Washed.	No. of Carats Found.	Value of Diamonds.	Yield per Load in Carats.	Value per Carat.	Value per Load.	Cost of Production per Load.	Profit per Load.
			£		s. d.	s. d.	s. d.	s. d.
1903	76,931	99,208¼	137,435	1.290	27 8.50	35 6.70	4 7.20	30 11.50
1904	939,265	749,653½	866,030	0.798	23 1.20	18 5.30	2 7.62	15 9.68
1905	1,388,071	845,652	994,687	0.609	23 6.29	14 3.98	3 3.44	11 0.55
1906	2,988,471	899,746	1,277,740	0.301	28 4.82	8 6.61	3 5.71	5 0.90
1907	6,538,669	1,889,986¾	1,702,631	0.290	18 0.20	5 2.49	2 4.14	2 10.35
1908	8,058,844	2,078,825¼	1,536,720	0.258	14 9.40	3 9.75	1 10.24	1 11.51
1909	7,517,793	1,872,136½	1,172,379	0.249	12 6.29	3 1.43	1 11.42	1 2.01
1910	9,331,882	2,145,832¾	1,496,641	0.230	13 11.39	3 2.49	2 0.56	1 1.93
1911	8,325,272	1,774,206	1,433,971	0.213	16 1.97	3 5.34	2 2.02	1 3.32
1912	9,707,098	1,992,474	2,004,943	0.205	20 1.50	4 1.57	2 4.79	1 8.78
1913	10,434,680	2,107,983	2,336,828	0.202	22 2.05	4 5.74	2 6.67	1 11.07
1914	7,683,943	1,417,755	1,259,643	0.185	17 9.23	3 3.34	2 5.89	9.45
1915	Mining operations suspended.							
1916	1,572,521	419,947	475,856	0.267	22 7.95	6 0.63	2 7.62	3 5.01
1917	4,928,629	906,341	1,198,923	0.184	26 5.48	4 10.38	2 2.68	2 7.60
1918	4,805,851	851,573	1,203,904	0.177	28 3.29	5 0.12	2 2.89	2 9.73
1919	4,529,261	814,577	1,961,259	0.180	48 1.84	8 7.92	2 10.68	5 9.24
1920	4,660,498	820,564	2,098,483	0.176	51 1.77	9 0.06	3 2.59	5 9.47
1921	1,954,230	411,981	439,626	0.211	21 4.11	4 5.99	3 4.43	1 1.56

This gives the following totals for the 18 years:

Number of loads washed	95,441,909
Carats of diamonds found	22,098,442
Value of diamonds	£23,597,698

The Nineteenth Annual Report of the Premier (Transvaal) Diamond Mining Co., Ltd., very naturally shows a reaction. The credit for diamond account was £439,636, and the balance carried to Expenditure

[1] Communicated under date of Aug. 27, 1921.

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and Revenue Account No. 2 was £110,384. After subtracting £20,000 for general equipment, this left £90,354 of realized profits, the 60-per cent. share of the Government being £54,212, and the 40-per cent. share of the stockholders £36,142, With the help of the previous year's balance of £40,964 and of sundry revenue totaling £100,188, the company was able to pay two dividends of 3s. 6d. on the preference shares, and carry £77,921 over to balance sheet. The two dividends (less 7½ per cent. Government tax) amount to £92,000. No dividend was paid on the deferred shares.

This left £464,731 as undistributed balance carried to next year, £354,381 of this being suspense profit account for diamonds unsold June 30, 1921. The general reserve fund then stood at £700,000, while the special reserve fund for the stabiliment of the diamond trade had been increased to £2,476,900 invested in the shares of other diamond companies and kindred interests.

The higher average weight of the diamonds from the Premier mine this year, namely 0.211 carat against 0.176 carat in the previous year, is attributed to the fact that much of the blue ground whence they were derived came from the levels near the surface of the mine, which, for various reasons, had not been worked out before, especially in the vicinity of the rim rock. On the other hand the average value of the diamonds per carat showed a very marked decrease, for in 1919–1920 this was £2 11s. 1.77d., whereas in 1920–1921 it fell to £1 1s. 4.11d., considerably less than half as much.

Of the prevailing depression in the industry, the preliminary report says:

> Your Directors in their report last year mentioned that there was then a lull in the demand for diamonds. Since that date the world generally has been passing through a period of severe depression, which has been felt most acutely in the diamond industry. For many months there was a complete cessation of sales by the Syndicate of diamonds purchased by them from the four large producers, and up to now no sales of any importance have taken place.
>
> In consequence of the stagnation in the diamond market and of representations by the Diamond Syndicate, meetings of the four large producers and the Diamond Syndicate were held at Cape Town in March and May of the present year, when matters were discussed and a satisfying arrangement as to the future deliveries was come to.
>
> The severe and continued depression compelled your Directors to take steps to curtail operations and to economize wherever possible, which unfortunately necessitated the retrenchment of large numbers of employees, both European and native. All mining work was stopped and expenditure in every department was greatly reduced.
>
> A slight improvement in the diamond market has been noticeable recently, but it is still necessary to exercise patience and economy, for the depression through which the ndustry is passing makes the present a difficult period.

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The statistics of working and production in the De Beers group of mines for the years 1917 to 1921 are as follows:

DE BEERS AND KIMBERLEY MINES

	Loads of Blue Ground Hoisted.	Loads of Blue Ground Washed.	Carats of Diamonds Found.	Selling Value per Carat.
1916–1917	None	None	41	Not Stated
1917–1918	None	None	315¾	Not Stated
1918–1919	None	None	241¾	Not Stated
1919–1920	None	None	242	Not Stated
1920–1921	None	None	955	Not Stated
WESSELTON MINE				
1916–1917	1,814,393	1,669,104	445,665¾	53s. 9.27d.
1917–1918	2,065,620	1,805,436	487,828¼	54s. 9.76d.
1918–1919	1,035,311	1,657,146	403,039¾	69s. 11.79d.
1919–1920	1,927,178	1,646,895	401,531½	119s. 1.25d.
1920–1921	845,295	832,442	217,761	136s. 0.54d.
BULTFONTEIN MINE				
1916–1917	2,092,267	1,761,756	675,401¾	46s. 11.00d.
1917–1918	2,328,615	1,859,531	646,927½	49s. 9.62d.
1918–1919	1,262,942	1,629,198	507,858¾	63s. 5.38d.
1919–1920	2,021,026	2,251,257	663,419¾	102s. 10.29d.
1920–1921	934,537	670,907	233,924½	109s. 4.26d.
DUTOITSPAN MINE				
1916–1917	135,650	1,927,335	377,571¼	106s. 11.93d.
1917–1918	2,200,000	2,178,132	422,657¾	108s. 6.22d.
1918–1919	1,389,883	1,066,465	180,983	139s. 9.77d.
1919–1920	1,796,573	1,892,558	305,587	221s. 2.36d.
1920–1921	861,651	830,424	132,497	248s. 4.68d.

GRAND TOTALS FOR ALL MINES

1913–1914	7,166,829	6,641,398	1,903,621¼
1914–1915	738,472	693,822	188,136
1915–1916	104,583	1,857,983	591,369¼
1916–1917	4,042,310	5,358,195	1,498,679¾
1917–1918	6,595,078	5,843,099	1,557,729½
1918–1919	3,688,136	4,352,809	1,092,123¼
1919–1920	5,744,777	5,790,710	1,370,780¼
1920–1921	2,641,483	2,333,773	585,137
1913–1921	30,721,668	32,671,789	8,787,576¼

The Thirty-third Annual Report of the De Beers Consolidated Mines, for the year ended June 30, 1921, reflects unmistakably the reaction in the diamond industry which had already set in during 1920. Still, the showing is more favorable than had been expected. On June 30, 1920, the undistributed balance amounted to £592,075, of which £354,244 represented the value of diamonds unsold at that date. The receipts from diamond sales during the year reached the quite respectable figure of £2,300,581; interests and profits on investments, and other revenue, amounted to £639,448, and there was a transfer of £1,010,232

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from the general fund. These items, added to the balance above noted, give £4,542,336 on the credit side. From this came £1,976,043 for mining expenditure, £143,425 for expenditure on farms and landed property, and on the Kimberley-Alexandersfontein Railway, £164,470 for interest on debentures and on capital of leased companies, and £84,-186 transferred to sinking fund towards repayment of debentures; and also charges as follows: donations, £66,105; grants to employees leaving the company's service in consequence of trade depression, £112,731; other charges, £164,537; in all, £343,373. These deductions having been made, there remained £1,830,829, available in part for distribution to shareholders, after setting aside £6593 for Union of South Africa income tax, and £119,505 transferred to stabiliment reserve. The preferred shareholders received £740,000 after deduction of tax (that is to say £800,000 less £60,000, or 40 per cent.), and the deferred shareholders £500,000, free of tax, or 20 per cent.

The net results of the mining operations of the year ending June 30, 1921, made but little change in the number of loads of blue ground remaining on the floors of the several mines, as is shown in the subjoined table, which also gives the average number of carats of diamonds in a hundred loads and the value per load.

DE BEERS MINE

	Carats per 100 Loads.	Value per Load.	Loads of Blue Ground on the Floor at Close of Year.
1916–1917	.....	.....	48,396
1917–1918	.....	.....	48,396
1918–1919	.....	.....	48,396
1919–1920	.....	.....	48,396
1920–1921	.....	.....	48,396
WESSELTON MINE			
1916–1917	27	14s. 6.22d.	2,752,386
1917–1918	27	14s. 9.59d.	3,012,570
1918–1919	24	16s. 9.55d.	2,390,735
1919–1920	24	28s. 7.02d.	2,671,018
1920–1921	26	35s. 4.46d.	2,683,871
BULTFONTEIN MINE			
1916–1917	38	17s. 9.94d.	2,665,777
1917–1918	35	17s. 5.16d.	3,134,861
1918–1919	31	19s. 8.03d.	2,768,605
1919–1920	29	29s. 9.94d.	2,538,374
1920–1921	35	38s. 3.29d.	2,802,004
DUTOITSPAN MINE			
1916–1917	19	20s. 3.94d.	2,411,618
1917–1918	19	20s. 9.22d.	2,434,329
1918–1919	17	23s. 9.22d.	2,757,747
1919–1920	16	35s. 4.70d.	2,661,762
1920–1921	16	39s. 8.91d.	2,682,410

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The cost of production per load of blue ground, the value per load, and the profit per load in the three mines of the De Beers group which were worked in 1919, 1920 and 1921, were as follows, according to the company's report:

1919.			
Wesselton	6s. 7.19d.	16s. 9.55d.	10s. 2.36d.
Bultfontein	5s. 6.39d.	19s. 8.03d.	14s. 1.64d.
Dutoitspan	4s. 9.39d.	23s. 9.22d.	18s. 11.83d.
1920.			
Wesselton	8s. 4.97d.	28s. 7.02d.	20s. 2.05d.
Bultfontein	7s. 3.99d.	29s. 9.94d.	22s. 5.95d.
Dutoitspan	6s. 8.48d.	35s. 4.70d.	28s. 8.22d.
1921.			
Wesselton	11s. 9.54d.	35s. 4.46d.	23s. 6.92d.
Bultfontein	11s. 0.51d.	38s. 3.29d.	27s. 2.74d.
Dutoitspan	9s. 7.90d.	39s. 8.91d.	30s. 1.01d.

It will be observed that despite increased cost of production, the higher prices realized give in each case a larger profit per load.

The stock of blue ground on the floors June 30, 1921, compares with the stock in 1920 as follows:

Mine.	1920. Number of Loads.	1921. Number of Loads.
De Beers	48,396	48,396
Wesselton	2,671,018	2,683,871
Bultfontein	2,538,374	3,022,659
Dutoitspan	2,661,762	3,173,226

Thus there was an increase in 1920–21 of 1,008,602 loads, showing that just so much more had been hoisted than had been washed during the year.

As to the falling-off in the sales, the Chairman stated at the general meeting, held in Kimberley Dec. 9, 1921, that while during the year ending Dec. 31, 1920, the company sold £4,628,882 worth of diamonds, the returns for the ten months from Jan. 1, 1921 to Oct. 31, 1921, showed that the total deliveries of diamonds for that period only amounted to £618,930, while the expenditures of the company for these ten months totaled £2,019,249, leaving a deficit of £1,400,313. Of course this has entailed a considerable reduction of the working force, but to obviate hardship as far as possible, and to aid those who were discharged in their search for work elsewhere, a sum of £100 was offered to each employee over 18 years of age on resignation, and £50 to those under that age. A large number of men are said to have availed themselves of this offer.

As an illustration of the reduction of the number of employees, there

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were employed on June 30, 1920, 3020 whites and 13,781 natives, while on Oct. 26, 1921, the company carried on its pay sheets 1636 whites and 2451 Kafirs. To over 100 old employees who are past work, there have been allotted fortnightly grants amounting in the aggregate to £13,680 per annum.

Under date of Aug. 27, 1921, Dr. Percy A. Wagner writes that the De Beers Consolidated Mines are erecting a huge direct-treatment plant to deal with the combined outputs of the Wesselton and Dutoitspan mines. The famous Kimberley mine has been definitely abandoned. The pumps have been pulled up, and water is rising in the mine at the rate of about 1 ft. in 24 hr.

The total value of the diamonds produced in the De Beers mines from their organization in 1888 down to June 30, 1917, was $506,545,448. To this must be added for the four years 1918–1921 the sum of $93,626,788, making in all $600,081,236 up to June 30, 1921.

Of the smaller mines we learn from Dr. Percy A. Wagner that the Blaauwbosch is still being worked as an open mine to the depth of 230 ft., this being a record for such a small mine. It is believed that this depth represents the limit here, and it is considered doubtful whether underground work would pay. In August it was reported that operations were to be resumed at the Monteleo mine. In the case of the Frank Smith mine, which was closed down after a six months' trial, the yield proved less than had been expected, but the quality of the diamonds was so good that the owners think the mine can be worked at a profit when the diamond market improves.

Regarding the Postmasburg occurrences, to the west of Kimberley, Dr. Wagner states that only the West End pipe has so far in any way fulfilled expectations. It has been proved to have an area of 150 claims and the yellow ground carries an average of about 20 carats to the 100 loads, the diamonds being of good quality. A large treatment plant is being erected, and as soon as this is completed washing operations will be begun. The Postmas Diamonds, Ltd., suspended operations during the early part of 1921, after a short period of working; the very unsatisfactory yield obtained was attributed to the bad design and working of the plant. One of the pipes opened up by this company has an area of 240 claims, and has been definitely proved to be diamantiferous. Whether it is payable or not remains to be seen. Two other pipes—the Smuts and the Bowden—have been located within a mile of the above-noted one. As to their areas or diamond content no definite information is available, but the general indications are considered so favorable that a company under the name of the Diamond Fields of Africa Exploring

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Co., Ltd., has been floated in London. All the pipes of this area are in dolomite, and hence the material is very strongly impregnated with calcium carbonate.

While in most of the South African diamond mines but little development work was carried on in 1921, the area of the Crown Diamond mine, formerly known as the Lace Diamond mine, has formed an exception to this general rule, for exploratory tunnels have been opened there to test the productivity of the western end of the mine. A mass of mixed material, largely "hardibank," has always constituted an obstacle to mining here, although the fact that blue ground exists around it has been proved by an exploratory tunnel driven through this mass at the 160-ft. level. Various test results from ground thus obtained were as follows: 1090 loads of blue ground furnished an average of 11.78 carats of diamonds per 100 loads; 458 loads showed an average of 16.7 carats per 100 loads; and 541 loads gave an average of 20.01 carats to each 100 loads. A drill-hole bored near the mouth of the exploratory tunnel passed out of "hardibank" into blue ground at 34 ft. This shows that the "hardibank" does not extend downwards, but rests upon blue ground. After the drill-hole had traversed blue ground to the depth of 202 ft., basalt was encountered. A similar result was given by exploratory drives put in at the 440 level in 1919, basalt being met with at the walls of the pipe, and in the exploratory drives at the 160-ft. level, a large mass of this rock was encountered which must have been thrown up from below, for only one sheet of this amygdaloidal basalt is known to exist in the mine.[1]

Concerning the alluvial fields Dr. Wagner notes[2] that the workers in these fields have suffered exceptionally from the slump in diamonds, and that the greatest poverty and distress prevailed in the diggings, more especially in the Bloemhof area, where things were so bad that the Government Inspector of white labor advocated the closing of the diggings, on the ground that they were causing mental and moral degeneracy in a large number of those connected with them. Nevertheless a new area has been proclaimed, known as Coetzee's Farm, adjoining Zwartlaagte near Bloemhof, and from 600 to 700 diggers have been attracted thither, but the finds have fallen much below expectations. The long-delayed proclamation of the farm Mosesberg, which has been the subject of much litigation, was eagerly awaited, for there were known to be extensive areas of rich gravel on this property, and 15,000 prospectors and miners were developing and mining in May, 1921. The farm is situated on the Vaal River above Smith's Drift.

The most interesting event of 1921 in the alluvial fields was the dis-

[1] *So. Afr. Min. Eng. Jour.*, Feb. 25, 1922.
[2] Communicated in letter from Pretoria, dated Aug. 27, 1921.

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covery in an abandoned claim at Gong Gong of a diamond weighing 381 carats, the largest ever found in the digging. Mr. Wagner tells us that the circumstances under which the find was made well illustrate the romance and vicissitudes of the alluvial diggings. Three men were trekking with a wagon and donkeys to Mosesberg, believing that the proclamation of the farm was imminent. In the neighborhood of Barkley West their donkeys strayed and were lost, with the result that the diggers were absolutely stranded. Eventually they decided to try their luck on this part of the river, and armed with picks and shovels they began operations at Gong Gong, on a claim which the former owner had abandoned in disgust. Within eighteen inches of the old working surface they unexpectedly turned up a big diamond. It was a large cleavage block, and proved to be of rather poor quality, but nevertheless, because of its size, it realized the sum of £2300, or nearly $9000, unheard-of wealth in the diggings at this time.

Brazil.—It has been reported that United States capitalists are negotiating for the purchase of three diamond mines in Brazil. The comparative activity of the Brazilian diamond field is shown by the fact that in 1920 diamonds worth $656,064 were exported, principally to England and the United States. In 1921, the exports were valued at $643,280. The diamonds came from the States of Bahia and Minas Geraes, the former contributing something over 50 per cent., mainly gathered by smaller mine owners. Minas Geraes has three chief producing companies, namely, the Boa Vista Diamond Mine Co. of Diamantina, which is controlled by Brazilian capital, although some 20 per cent. of the stock is owned in England; Cascalio & Co., of Diamantina, controlled by English capital, and the Sopa mine of Diamantina, which was formerly owned by a French company, but is now controlled by Brazilian capital. The estimates of total production are a little uncertain, because many subterfuges are used to avoid payment of the export taxes, but the product is said to be worth about 1000 contos of reis per month, or about $136,000.

Brazil is the great source for the carbonados, or amorphous black diamonds which are so successfully utilized for drilling; these come principally from the State of Bahia. The exports for the three years have been as follows: 1919, 2423 contos ($329,528); 1920, 3017 contos ($410,312); 1921, 2616 contos ($355,776).

Apart from diamonds, Brazil produces almost all the known semi-precious stones, the most important being aquamarines, rock-crystal, amethyst and tourmaline. This industry is in the hands of small groups of individual miners who work on a profit-sharing basis, the sales being made to local traders.

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British Guiana.—While the diamond output of British Guiana is not very large, it can scarcely be called a negligible quantity, for in the 20 years from 1901 to 1920, diamonds weighing in the aggregate 216,581 carats were produced, the best returns being for the year 1920, when 39,362 carats of diamonds were found. This means nearly four times the average for the previous 19 years, and was in great measure due to the discovery of rich deposits on the Kurupung River, in the neighborhood of the older diamond fields. In these new deposits has been found a diamond weighing 29⅜ carats the largest, so far recovered in British Guiana.

Venezuela.—Diamonds have been found recently in Venezuela, in gravel of the Caroni River. The local fancy is that they originated in the mountain chain called Roraima, near the headwaters of the Caroni. As these diamonds were found in the placer deposits and mixed with the gravel, our informant, Mr. Edward H. Emerson, believes that they must occur in the same formation as the gold quartz. Only two rocks have been recognized, one being a greenish schist of which the residual gold deposits have been formed, the other being a coarse diorite, which decomposed into a coarse sand. This diorite contains fine gold, in places, but gives no such concentrated placers as the more easily decomposed schist; still our informant does not venture to say whether the diamonds originally occurred in the schist or in the diorite, and he admits that there may be some other rock farther up the river from which they may have come.[1]

Pearls

Arabia.—The Arabian fisheries are guaranteed by the British Government, inasmuch as no one but the native Arabian is permitted to fish for pearls. This control was attempted some years ago. Some French officers endeavored to undertake the fishing, but the British Government interfered, and the matter remains entirely in the possession of the Arabians, who have carried it on from time immemorial.

Victor Rosenstein of Bahrein, Arabia, is the largest buyer, purchasing nearly all the pearls found there. Among these there was one the size of a good-sized marble, for which he paid £6000.

China.—In the borderland between Kiang-Sou and Che-Kiang in China there are many lakes wherein the pearl oyster has taken up its abode. The fishing rights are held by the owners of these lakes, but they rent out the privilege of exploitation. Of the fishermen who secure this right some pay for fishing during an entire year, while others, who have another regular vocation, pay a small amount for a single day's fishing.

[1] Communicated by Mr. Edward H. Emerson, in letter of Mar. 20, 1922.

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There are said to be from 700 to 800 boats used in the exploitation. Such pearls as are found are sold to dealers who take them to Shanghai, where they sell them at a large profit.

Madagascar.—The President of the French Republic has issued a decree, on the recommendation of the Minister of the Colonies, authorizing the granting of concessions for the fishing for pearl oysters, nacreous shells, and sponges in the territorial waters of Madagascar. All persons who, before the promulgation of the decree, had acquired rights of fishing, have the privilege of changing these rights into concessions, if they make the demand within six months. The customary fishing rights of the natives are to be regulated by the Governor General of the Island. Concessionaires who wish to establish a culture station are to submit the project to the Governor General. All the concessions are to be personal and temporary, although some modification in the terms may be accorded on due application. Each concession has a duration of ten years, but it may be renewed where sufficient justification is proven; they are also revocable in case the exploitation is interrupted for one year, or the rental is not paid, and for a few other reasons. The use of dredges, or other means of dredging, is only authorized for depths exceeding 20 meters, and the Governor General can prohibit the use of such machines on the whole or any part of the concession, when this becomes necessary for the replenishing of the beds.[1]

Other Precious Stones

Australia.—The Australian sapphire fields have been passing through a sort of crisis recently in the recoil from the prosperity of 1919. To stabilize the market the Government entered into an agreement with a firm of gem dealers having offices in Bombay, Paris and London. This firm was to be sole agent for the sale of the sapphires, for a term of three years, each party having the right to terminate the contract on three months' notice. A ruling monthly price for the sapphires was to be announced each month, and the Government agreed to advance 75 per cent. of this price to the individual miners, the balance, less charges, to be paid them when the gems were sold. This agreement was later abrogated.

After February, 1921, when the arrangement concluded by the Australian Government was resumed, Anakie sapphires to the value of £20,000 were soon sold, the price commanded by first-grade parcel blues being £7 11s. per oz. This activity lasted for a while, though on a

[1] Recueil Mensuel des Procès-Verbaux des Séances de la Chambre Syndicales des Négociants en Diamants, Perles, Pierres Précieuses, et des Lapidaires, No. 57, March, 1922, pp. 951–954.

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diminishing scale, until in September the agreement was terminated. The official returns of gem-stones from this field are thus given:

Parcel blues	£40,354	15s.	10d.
Fancy stones, locally cut	1,192	0	0
Mechanical stones, machine and corundum	4,976	17s.	4d.
Total	£46,523	14s.	2d.

This compares with an output of £64,050 in 1920, showing a decrease of £17,527 in value. But little prospecting was done in this region, a few miners, who went to try their luck at Tomahawk Creek having returned unsuccessful. Some attempts to develop the new find at Woodbine had no satisfactory result; the quality of the sapphire found here does not compare favorably with that of the Anakie field.[1]

Opal mining was almost abandoned in the Australian fields in 1921, the only official returns being 36 oz. worth £100.

In May, 1920, a deputation waited on the Minister for Mines in New South Wales, and inquired whether the Government contemplated improving the facilities for the marketing of the black opal in the Lightning Ridge district. The Minister replied that about 90 per cent. of the output was acquired on the field by some fifteen buyers, and was sold by them to a single buyer in London, who thus practically controlled the price. The Minister also stated that the Mines Department had no available funds for the purchase of precious stones, but that if the deputation would report the number of stones in the hands of the miners, he would collect information as to market conditions. It is considered doubtful whether the 200 or 300 opal miners now operating at Lightning Ridge would be able to remain in case the prices should be depressed.

Brazil.—A number of large aquamarine beryls were found in Brazil during 1921. Of these the largest came from the Marambya mine and weighed 331.3 grams; another from the same mine weighed 213.2 grams. One from the Verruga mine had a weight 237.7 grams. The Marambya mine furnished three other aquamarine crystals with respective weights of 48.3 grams, 39.7 grams, and 34.3 grams; a smaller one came from the Cerro mine and weighed 18.5 grams. Another Brazilian source, the Citubina mine, produced a lot of 108 aquamarine crystals with an aggregate weight of 984.5 grams.[2] Other precious-stone material from Brazil in 1921 comprised a great tourmaline crystal weighing 1623 grams, a topaz with a weight of 41,400 grams, a rich blue topaz of 11,407 grams, a wine-colored topaz of 24,499 grams, and a transparent beryl of 27,215 grams.

[1] *Queens. Govt. Min. Jour.*, Apr. 15, 1922.

[2] The greatest crystal of aquamarine ever found was at the Marambya mine, on Mar. 28, 1910. It weighed 110.5 kg. (243.1 lb.). It was described by George F. Kunz (New York Academy of Sciences, Apr. 3, 1911, and *Am. Jour. of Science*, **31**, 463 (1911)).

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India.—The report of the Burma Ruby Mines, Ltd., for the year ending Feb. 28, 1921, shows a marked reaction from the results of the preceding year, for the Income and Expense Account exhibits a loss for the 12 months of £5929 13s. 6d., while on Feb. 28, 1920, there was a surplus of £4359 3s. 10d. This leaves a net deficiency of £1570 9s. 6d. During the year 771,406 truck loads of ruby earth were washed, against 754,324 loads in the previous year, but the value of the stones recovered only amounted to £43,010 as compared with £76,153. However, the large total for 1919–1920 included the value of the great "Peace Ruby" of 42 carats, valued at £20,000. This is also reflected in the decreased amount of sales, namely £33,507 for 1921–1922 against £91,601 in 1919–1920. Still there continues to be a steady demand for the ordinary qualities in India and Burma, and fine stones always find a good market in London and Paris. As the new sluicing system which has been introduced was only in action for seven months, it was not possible to compute the cost of production per load for the entire year. The report states that the poor result of the year's mining is accounted for by the almost complete absence of important and valuable stones. Expenses remained practically the same as before.

Aventurine of great interest is noted in a communication made at a meeting of the London Mineralogical Society on Jan. 10, 1922. H. H. Thomas and E. G. Radley stated that the so-called "aventurine" from India is a quartz-schist, and owes its color to plates of green fuchsite arrayed parallel to the planes of foliation. The mica contains 1.77 per cent. of chromium oxide and a little vanadium. This beautiful material, very inexpensive, has found a great sale in the form of necklaces, enjoying the favor of the rich imperial jade.

Mexico.—A mineral which has not heretofore been found in the region of Guadalcázar, State of San Luis Potosí, and one which is rather rare in Mexico, is the bluish-green variety of beryl known as aquamarine. It occurs in hexagonal crystals, or crystalline masses, up to 1 cm. in length, but rarely has the crystallographic faces and angles. The mother rock of this beryl is a pegmatite, containing besides quartz a great quantity of microscopic crystals of topaz, and a number of other crystallizations so far not determined, but which may perhaps be combinations of rare earths. Dr. Wittich found this pegmatite in the contact zone of the granitic "Realejo" in the ravine of the stream Los Arcos. In the pegmatites, beryl is a mineral of frequent occurrence, and is probably a pneumatogenic product, for it generally contains great quantities of gases, even of helium.[1]

[1] E. Wittich and Dr. I. Kratsert, "Contribuciones a la Mineralogia Mexicana" Memorias y Revista de la Sociedad Científica "Antonio Alzate," Vol. 39, Nos. 9–12, pp. 659, 660, Mexico, Dec., 1921.

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Madagascar.—A valuable contribution to our knowledge of the gem minerals of Madagascar has recently been made by Prof. Alfred Lacroix, of the Muséum d'Histoire Naturelle.[1] The writer stated that although from its discovery the Island of Madagascar enjoyed the repute of possessing valuable gem deposits, a Frenchman who visited the Island as early as 1547 having declared that precious stones existed there, still it is only from 1891, thirty years ago, that we can really date their discovery. At that time M. A. Grandidier gave to the Muséum a fine crystal of rubellite and some small sapphires and zircons found there, as a general rule either from the eluvials (wind-drift) covering pegmatite veins, or else in the pegmatite itself, only very rarely in alluvial deposits. The most prized of these Madagascar gems are the beryls, which occur in a great variety of beautiful colors, yellow, blue, sea-green (aquamarine) and rose-pink. The latter contains a small amount of caesium and on those of a peach-bloom hue, or of a salmon-pink, the name "morganite" has been bestowed. Then there are tourmalines in great variety of coloration, the kunzite variety of spodumene, fine garnets, some topazes and a very few sapphires and rubies. To these should be added spinels, crysoberyls, zircons, cordierites, diopsides, amethyst and citrines. Especially characteristic are gem examples, such as have not been found elsewhere, of the following: kornerupine, danburyite, scapolite, and ferriferous orthoclase.

We are informed that the French Government has entrusted to Prof. Lacroix and M. Vielle-Koechlin the task of assembling a complete collection of the gems found in the great French colony of Madagascar. The work of bringing together the very numerous specimens is nearing completion, and the collection will be exhibited at the French Colonial Exhibition in Marseilles to be held early in 1922. Prof. Lacroix is our greatest authority on Madagascar minerals, on which he has just issued a magnificent work, published at Government expense, and embodying the results of many years of research carried on by him in this great island.

Russia.—One of the reviving industries in Soviet Russia is the mining of Uralian precious stones. This is now to be carried on systematically and on a large scale, for the report drawn up by the Mining Department of Ekaterinburg assumes an output of 825 poods, or nearly 30,000 lb. Of course the term "precious stone" must be taken in a very wide sense as covering all decorative stones as well as gems suitable for jewels. Already, in the summer of 1921, the initial steps in this mining had been taken, indeed work in deepening the already existing shafts had been

[1] A. Lacroix, "Les Pierres de Madagascar," lecture given at the Muséum d'Histoire Naturelle, on Apr. 10, 1921. It is a résumé of a chapter from the second volume of the forthcoming work by the same writer, entitled, "Minéralogie de Madagascar."

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started in October, 1920. Among other stones, aquamarines and tourmalines are mentioned. The material is to be cut and facetted in the great workshops at Ekaterinburg, which were established by two Italians at the command of Catherine II. The polishing equipment here is said to be sufficient to treat 21,000 carats at one time. All the stones taken out can be utilized in one way or another, if not for jewelry or decoration work, for rich vases and the like, then for mineralogical collections. For these Ekaterinburg is the only Russian source and the demand is said to be great. A party of Americans who traversed the Urals in 1921 are stated to have secured a number of specimens, but the steady and regular demand comes from the "Société Uralienne des Naturalistes," of which the writer was elected an Honorary Member in 1892.

The District Government has determined to keep the exploitation of the mines in its own hands, although numerous applications have been made by private persons and companies.

The writer visited the Urals in 1891, and found that the finest beryls, topaz, and amethysts were discovered in the Government of Perm, notably at Alabaska and Musuka, where many of the most wonderful crystals of these gem minerals were found, and these now grace the mineral cabinets of the world.

The amber which is found in coastal deposits in East Prussia, principally along the shores of the Samland Peninsula, is recovered partly by dredging operations and partly by excavation. Smaller quantities are obtained on the coast of the Baltic between Danzig and Pillau, and from Oranz to Memel. The amber is owned by the Public Amberworks in Königsberg, Prussia. Much of the material is worked up into ornamental forms in Danzig, both natural and molded amber being used. The articles include necklets, brooches, pendants, ear-rings, rings, paper-cutters, seals, penholders, cigar and cigarette holders, and many kinds of pipes. Besides these amber beads are exported to Africa, buttons to China and Japan, and rosaries to Mohammedan lands. Amber is also manufactured in combination with the precious metals. The amber guild of the Free and Hanseatic City of Danzig dates back to the fifteenth century, having originated in 1477, and the industry has constantly developed since then, so that at present its repute is world-wide. In order to protect their interests, the amber manufacturers of Danzig have organized a union bearing the name "Vereinigte Bernsteinwaren—Fabrikanten E. V. Danzig."

Southwest Africa.—In Southwest Africa, about two kilometers east of Usakos, a most important discovery of gem tourmalines has been made, in an intrusion of pegmatitic granite in schist. The tourmalines

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occur in crystals up to 2 ft. in length, and bluish-green stones predominate, but the rare dark-blue variety known as indicolite is also reported. Dr. Percy A. Wagner has had a number of them cut and states that they are most brilliant and flawless, constituting very handsome gems.[1]

The discovery in 1910, by Dr. E. Reuning, of aquamarines and rose-quartz in pegmatite about three miles to the north of Rössing Station, and about a mile to the east of the Hanoas (Knife) Hills, has already been noted in a previous report.[2] It is stated that now, under the new control of the Southwest African region by the Union of South Africa, operations were resumed early in 1921, and when the district was visited in March by Dr. Percy A. Wagner, a white man and a number of natives were working there.[3] The most noted of the gem material found by Dr. Reuning was the golden-hued beryl on which the name heliodore was bestowed. Dr. Wagner notes that the heliodore of these pegmatites contains appreciable quantities of uranium oxide, and is distinctly radio-active. This he takes to indicate that the pegmatite solution from which the pegmatite crystallized was itself radio-active.

Besides the "heliodore," there are to be found in the pegmatites near Rössing Station other fine beryls, notably beautifully clear, transparent, flawless crystals of a light blue or pale bluish-green hue. At Swakopmund, there was shown to Mr. Wagner a very fine necklace of pale, sky-blue aquamarines cut in Paris. Then there are other beryls, clear transparent to translucent crystals of a fine yellowish-green color, which seem to correspond to the variety of beryl known as aquamarine chrysolite that is found in Siberia and Brazil. By daylight the color of these stones strongly resembles that of the heliodore when seen by artificial light.[4]

United States.—As to the precious-stone output of the United States, the diamond deposits near Murfreesboro, Ark., discovered in 1906, have produced quite a number of diamonds. The largest stone found here so far weighed 20.25 carats and was of good color, though having a number of flaws; it furnished, when cut, a marquise stone of 4.15 carats valued at $3000. Another diamond weighing 18.03 carats has also been found here. During the coming year this mine will be worked with improved machinery. However, by far the largest yield of precious stones has been afforded by the sapphire mines of Yogo Gulch, Fergus County, Mont.; the value of these sapphires represents fully one-half of the total output of precious stones. Possibly about one-fifth of the total can be

[1] Communicated by Dr. Percy A. Wagner, in letter dated Mar. 13, 1922.
[2] MINERAL INDUSTRY, 21, 728 (1912).
[3] "On Some Occurrences in the Namib Desert." Percy A. Wagner, *Trans. Geol. Soc. of So. Afr.*, 4, 86 (1921).
[4] "Some Mineral Occurrences in the Namib Desert." Percy A. Wagner, *Trans. Geol. Soc. of So. Afr.*, 24, 92 (1921).

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credited to tourmalines, almost all from California, although a few came from Maine. Turquoise and turquoise-matrix from Arizona, New Mexico, California, and Nevada furnished about one-tenth of the total. The balance were quartzes, the so-called copper silicate, and moss agates, principally from California and the Coast States, and utilized chiefly for the tourist trade. At final retail prices, it may be estimated that $1,000,000 worth of precious stones of United States origin have been sold since the beginning of the World War. A good part of this price is of course due to the expense of cutting, and to the profits of the various hands through which the stones passed.

Amethysts have recently been found and mined in Arizona to a notable extent on the claims near the Roosevelt dam, discovered by W. S. McDaniels. Orders for material to the amount of $2000 have been obtained from lapidaries and dealers in Los Angeles, the crystals having been taken from but 20 in. below the surface of the ground. This is the first amethyst deposit of commercial importance in Arizona.

Jade has never been more sought after nor held at a higher price than at the present time. It is also interesting to note that in addition to jade there has been used a compact idocrase, californite, described by the present writer, and which comes from California, as well as the compact pectolite found in Alaska, and the barenite which occurs in Rhode Island and in various parts of China. There was also noted this year a remarkable occurrence of compact garnet, resembling jade, discovered in Alaska by Commander Emmons and described by Henry S. Washington.

One of the results of the World War has been a revival of interest in what is denominated as "mourning jewelry," whether made of jet, or of black onyx, in combination with some white stone such as moonstone, for example. In this connection it is interesting to report the discovery of large deposits of jet in what is known as Coal Basin, at the foot of the Henry Mountains, Wayne County, Utah. About 14,000 linear feet of the outcrop of the stratum containing jet has been exposed, and the mineral has been found occurring promiscuously, here and there, all along the exposed stratum in the form of flattened-out trees, the tree-trunks, limbs, roots and bark having all been metamorphosed with jet. Geological conditions make it clear that these trees were at one time buried or covered to a depth of approximately 2000 ft., and there is no doubt that the pressure of this tremendous overburden flattened out trees probably a foot or more in diameter until their thickness was reduced to from 1 to 6 in., thus closing all the pores of the wood. The heat generated by this enormous and long-continued pressure produced a state of fossilization resulting in the present deposits of jet. This burying of the trees must have occurred ages ago, probably at the time of the

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great uplift when the Henry mountain range punctured the great southern Utah desert, rearing up peaks thousands of feet high. In the course of further ages the water derived from the melting snow on the mountain slopes cut a deep chasm out of the earth's crust, which deepened and widened until at last an oblong basin was formed, thus exposing the stratum wherein the jet trees now lie for about 14,000 linear feet. A tough hard fireclay from 1 to 2 ft. thick now overlies the jet, the balance of the overburden being extremely soft, so that it can readily be sluiced off by water, when it is a simple matter to peel off the layer of clay. This operation is favored by the existence, at an elevation of about 600 ft., of a spring of water which can be piped down to the jet workings. In some cases nearly complete "jet trees" were found, the limbs, roots and bark being of this mineral. The bark was so well preserved that it is possible to determine that at least three different kinds of trees have been converted into jet. It is claimed that there is enough jet here to supply the world for centuries.[1]

The turquoise as used by the Zuñi Indians of New Mexico in early times is the theme of an attractive publication, issued by the Museum of the American Indian Heye Foundation.[2] This gives very reliable and satisfactory information on the matter, and also regarding the location of the deposits whence the material was drawn. The principal sources, both in early and modern times, have been the Cerillos mountains of New Mexico, about 20 miles south-southwest of Santa Fe. Still, a few other deposits were worked to a limited extent, such as some in the Burro and Little Hichita mountains in Grant County, and in the Jarilla hills in Otero County. It is considered unlikely that the Zuñi Indians extracted the turquoise themselves; they more probably secured it by trade with Rio Grande Pueblos. Later, when corporations obtained control, and Indian quarrying was practically abandoned, white traders were the sources of supply. In early times, owing to the difficulty of transporting the turquoise for long distances without the aid of animals, the material was much rarer than is the case today, although it must not be forgotten that Pepper found over 50,000 worked pieces of turquoise in his excavations at Pueblo Bonito. That it was used for ornamental and sacred purposes by the Zuñi who dwelt in the now-ruined pueblo of Hawikuh has been proved by the results of the excavations carried on there lately. The earliest notice of the use of turquoise in this region is that furnished by Fray Marcos de Niza, concerning his journey to Cibola in 1539.

[1] Communicated by Mr. J. C. Gustaveson, Ogden, Utah, in letter dated Apr. 12, 1922. The black and white jewelry which has been so much favored may consist of onyx with a tiny border made up of caliber-cut stones or intermingled with white diamonds in a platinum setting, or also crystal with onyx or jet.

[2] F. W. Hodge, "Turquoise Work of Hawikuh, New Mexico." Leaflets of the Museum of the American Indian, Heye Foundation, No. 2, New York, Mar. 22, 1921, 30 pp., 2 colored plates and text illustrations.

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During the excavations conducted at Hawikuh by the Hendricks-Hodge expedition in 1917–1920 there were found various examples of turquoise beads and small pendants of the solid stones, as well as several hair-combs and ear-tablets, and a breast ornament, all incrusted with turquoise on bases of wood.

Regarding the Los Cerillos mines the present writer noted in 1890 that whatever work was carried on there was done in a very desultory way, either by local lapidaries, poor whites, or Indians. The method followed is to build large fires against the base of the rock until it becomes thoroughly heated, when cool water is thrown over it. The abrupt change of temperature induces large pieces of the rock to crack off; but much of the precious material is ruined in this way. From these broken-off pieces of rock the turquoise is picked out of the exposed seams with pieces of pointed iron, such as old barrow-teeth, or any other sharp-pointed instrument. Only occasionally was a blast put in.[1]

Technology

The intensity of X-ray reflection by the diamond has been investigated by Sir W. H. Bragg, who read a paper on the subject before the Physical Society of London, May 27, 1921. An interesting feature was that if the outer electrons of the carbon atom lay at any considerable distance from the center, they must be in motion over a wide range, or else for some other reason contribute little to the reflection. It also appeared that the properties of the carbon atom in diamond are based on a tetrahedral, not on a spherical form.[2]

In his Presidential address[3] before the Mineralogical Society of America, delivered Dec. 29, 1921, Prof. Charles Palache of Harvard University passed in review the chief results of the investigations made regarding the "diamond-pipes" of South Africa, noting the valuable information given in Dr. Wagner's book on the South African mines.[4] After admitting that in his view the exact mechanical process by which these vertical holes have been produced has so far not been elucidated, Prof. Palache turns to the question as to the determining causes for the differences in the characteristic qualities of diamonds from different "types" and for the very unequal distribution of diamond material in some of them, and their absence from others. In regard to the latter he said:

[1] George F. Kunz, "Gems and Precious Stones of North America," New York, 1890, pp. 56, 57
[2] *Chem. News*, June 17, 1921, p. 285.
[3] "Some Problems of Mineral Genesis in South Africa," Presidential Address, presented at the Second Annual Meeting of the Mineralogical Society of America, Amherst, Mass., Dec. 29, 1921. *Am. Mineralogist*, March, 1922.
[4] Percy A. Wagner, "The Diamond Fields of South Africa," Johannesburg, 1914.

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"The explanation of the apparent total absence of diamonds in many pipes and of these local variations in character of the stones is probably to be found in the delicate equilibrium existing between the molten magma and the carbon in solution. Goldschmidt and Fersmann showed in their study of diamond crystals that the forms of growth and of solution were markedly different; that few crystals had escaped solution etching; and that a crystal might even have been growing on certain faces in the same magmatic solution that was dissolving material from other faces.[1] The control of the saturated condition of the solution is thus sensitive, but its nature is quite unknown. It may well be temperature or pressure, or the presence of other dissolved substances. The latter would be most likely to cause variation of color or other physical characters of the diamond crystals. And for the absence of diamond from so many pipes, at least two explanations may be suggested. Carbon may never have been present in the magma of a particular locality. It seems more likely that it is always present, but may be held in solution by peculiar chemical or physical conditions through the cooling period in which diamond can form and thus remains in solid solution in the rock. The ultimate source of the carbon is of course problematic. The sporadic distribution of diamond in the pipes might be explained by postulating local digestion in the magma of older, carbon-containing rocks. But it seems more probable that it is derived from the dissociation of cardon oxide gases in the magma, the carbon separating under favorable conditions as diamonds."

[1] A. von Fersmann and V. Goldschmid, "Der Diamant," Heidelberg, 1911, p. vii.

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QUICKSILVER

By W. D. Burcham

Preliminary figures showing the production of quicksilver in the United States in 1921, compiled by F. L. Ransome of the U. S. Geological Survey, give a total of 6339 flasks, as compared with 13,392 flasks in 1920. Of this output 3094 flasks is credited to California, 3144 to Texas, 100 to Nevada, and 1 to Idaho. So far as could be learned, Oregon produced no quicksilver in 1921.

In California seven mines reported production, but the output from all but the El Senador mine, of the New Almaden group, was small. The New Idria mine, for many years the largest producer of quicksilver in the United States, was idle in 1921. In Texas the Chisos was the only mine that remained continuously productive, but a small output was expected in December from the Mariscal mine, near McKinney Springs, and is included in the total. In Nevada about 100 flasks was obtained in the Pilot mountains, east of Mina. The single flask reported from Idaho was retorted incidentally to development work in the Yellow Pine district, Valley County. During the year the United Mercury Mines Co. acquired over 100 claims that were formerly held by the Idaho Quicksilver Co., the Monumental Mercury Mines Co., and other companies in the Yellow Pine district.

In Oregon, the War Eagle Mining Co., operating what was formerly known as the Rainier mine, in Jackson County, completed a 25-ton-Scott furnace in 1920, but is not known to have produced any quicksilver in 1921.

The average price of quicksilver in 1921 per flask of 75 lb., as quoted by the *Mining and Scientific Press* for the San Francisco market, was $47.42. The highest monthly average was $50, in January and May; the lowest was $40.40 in November. The average for December rose to $49.50.

The market price in New York as quoted by the *Engineering and Mining Journal* averaged $45.46 per flask for the year, with the high mark of $49.55 in February, and the low mark of $39.80 in November. This is the first time that the San Francisco market was higher than that of New York, and was caused by the European importations having greater weight than the production of California.

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MONTHLY AVERAGE PRICES OF QUICKSILVER
(Per flask of 75 pounds)

Month.	San Francisco.					New York.		
	1917.	1918.	1919.	1920.	1921.	1919.	1920.	1921.
January	$80.20	$115.58	$103.07	$89.00	$50.00	$105.50	$90.19	$48.440
February	116.25	116.96	91.45	81.00	48.75	89.84	84.43	49.545
March	112.50	115.83	73.68	87.00	45.88	71.56	92.61	46.796
April	115.00	115.46	71.20	100.00	46.00	72.94	102.19	45.423
May	105.00	113.30	78.60	87.00	50.00	83.12	89.56	47.000
June	86.20	113.48	89.83	85.00	49.50	93.25	90.15	46.846
July	102.18	116.69	98.85	88.00	47.75	104.68	90.33	44.950
August	111.10	118.33	103.73	85.00	47.50	107.08	83.81	45.028
September	110.90	119.00	99.83	75.00	47.50	102.52	75.00	42.660
October	100.62	119.33	86.23	71.00	46.25	86.35	67.20	39.840
November	100.75	118.91	82.28	56.00	40.40	90.74	58.42	39.804
December	111.65	115.60	91.13	52.50	49.50	98.27	49.58	49.212
Year	104.36	116.54	89.16	79.66	47.42	92.15	81.12	45.462

AVERAGE PRICE OF QUICKSILVER IN SAN FRANCISCO
(Per flask of 75 pounds)

Year.	Price.	Year.	Price.	Year.	Price.
1911	$46.01	1915	$85.80	1919	$89.16
1912	42.05	1916	125.25	1920	79.66
1913	40.23	1917	104.36	1921	47.42
1914	49.05	1918	116.54		

Never before has the quicksilver industry in the United States sunk to so low an ebb. The first recorded annual production was 7723 flasks, in 1850, and from that year to 1920 inclusive the annual output has been 10,000 flasks or more—in fact in only five years has it been less than 20,000 flasks. In 1859 it was 13,000 flasks; in 1860, 10,000; in 1908, 19,750; in 1914, 16,548; and in 1920, 13,392. The maximum output, that of 1877, was 79,395 flasks. The output in 1921 was thus the smallest on record. The average price in 1921, although of course much lower than that for the years during and immediately after the war, nevertheless compares favorably with pre-war prices. The average price during the 10 years from 1904 to 1913, inclusive, was $42.32, or $5.10 per flask lower than the average in 1921. The cost of production, however, has not declined so rapidly as the price, and no large bodies of ore are now known that are comparable in tenor to those that were exploited when quicksilver mining in the United States could be considered a flourishing industry.[1]

At present, the industry is practically dead, with most of the mines completely closed down, their organizations scattered, and, in most instances, without sufficient capital to resume normal operations. The primary cause of this condition is the large importation of European metal in the last six months of 1920, and about 10,000 flasks during the

[1] *Min. Sci. Press.*

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first nine months of 1921. These importations, together with considerable stocks held by domestic producers on a market already affected by curtailed consumption in the United States, has forced the market as low as or lower than pre-war prices.

STATISTICS OF QUICKSILVER IN THE UNITED STATES

Year.	Production. (b)					Exports.			Imports.	
	Calif. (a)	Texas.	Others.	Total.	Value. (f)	Flasks.	Metric Tons.	Value.	Pounds.	Value.
	Flasks.	Flasks.	Flasks.	Metric Tons.						
1907	(d)17,532	3,000	400	712	$868,678	5,132	175	$192,094	16,566	$6,719
1908	(d)16,969	2,832	346	685	903,391	2,995	110	124,960	15,113	8,215
1909	16,217	4,188	810	704	941,233	6,803	231	266,243	15,968	8,203
1910	(d)18,536	3,382	500	763	1,054,991	1,923	65	91,077	667	381
1911	(b)18,860	(g)2,396	.....	732	989,254	291	10	13,995	471,944	251,386
1912	20,600	2,700	1,847	855	1,067,742	310	14	13,360	82,706	39,919
1913	15,396	(h)	4,285	670	774,054	1,140	39	43,574	171,653	75,361
1914	11,485	(h)	5,083	536	811,832	1,446	49	70,753	685,605	300,000
1915	14,000	(h)	7,033	716	1,768,225	3,370	115	225,509	421,884	282,852
1916	(b)21,045	(g)3,504	383	1,018	3,768,139	8,880	302	670,475	424,396	515,919
1917	(b)23,938	(g)11,788	433	1,237	3,808,266	10,778	366	998,470	390,525	448,032
1918	(b)22,664	(g)9,495	724	1,119	4,060,064	3,098	105	338,620	503,925	533,622
1919	(b)15,205	5,019	1,191	738	1,933,560	9,107	309	817,328	797,625	791,226
1920	(b) 9,366	3,601	103	455	1,041,156	1,553	53	129,993	1,072,650	971,510
1921	(b)3,094	3,144	101	216	298,194	393	13	18,869	1,640,550	994,435

(a) Reported by the California State Mining Bureau, except as noted. (b) Figures of the U.S. Geological Survey. (d) Figures collected by MINERAL INDUSTRY. (f) Computed at average price at New York. (g) With Nevada. (h) Included in other states.

TARIFF

At present and for many years in the past, a tariff of 10 per cent. *ad valorem* has been imposed on quicksilver. In framing the new tariff bill it was first proposed to impose 7 cts. per lb. or $5.25 per flask on quicksilver, but in July a letter was written by the Secretary of War to Congressman Tilson urging that a tariff on imports be imposed that would enable this industry to be operated on a profitable basis in time of peace in order that the needs of the country in war might be met by the resources of the United States. In response to this a duty of 35 cts. per lb. was imposed, but later was reduced to 15 cts., and then a compromise figure of 25 cts. was adopted, which appears likely to stand when the tariff measure is finally passed and signed by the President, should such a culmination ever occur.

QUICKSILVER IN FOREIGN COUNTRIES

Production and Costs.[1]—At present, Germany is entirely out of the world's quicksilver market. Italy annexed the Austrian territory that included the Idria mine, and now owns and operates it as a government institution. An Italian company acquired the German interests at

[1] H. W. Gould, *Eng. Min. Jour.*, Jan. 21, 1922.

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Monte Amiata during the war, and today this district is the largest producer in the world, and, with the Idria, gives Italy over one-half, and, possibly two-thirds, of the world's production of mercury. Though Spain's production dropped from nearly 37,000 flasks in 1914 to 23,000 flasks in 1921, the Almaden mine is still yielding about one-third of the world's total.

WORLD'S QUICKSILVER PRODUCTION
(In flasks of 75 pounds)

	Spain.	Italy.		United States.	Miscellaneous.	Total.
		Idria.	Monte Amiata.			
1909	40,933	19,294(a)	22,668	21,075	4,500	108,470
1913	36,619	26,710(a)	31,541	20,213	4,000	119,083
1917	25,133	25,000(a)	29,300	36,159	4,000	119,592
1921(b)	23,000	10,000	30,000	6,339	2,000	71,339

The average cost in Europe of producing quicksilver is about $30 per flask. Adding $3 (10 per cent. *ad valorem* duty) and $2 for freight and other charges, to this cost, makes a total of $35 per flask f.o.b. New York. If the European producer can sell at $40 per flask, he makes a fair profit.

If the effort were necessary, even with their present antiquated methods, the Almaden mine, in Spain, could produce quicksilver for less, on account of the very high-grade ore (7 or 8 per cent.). The ore of the Italian mines averages from ¾ up to 3 per cent. and they have splendid reduction plants, good engineering practice, and—most important—plenty of cheap and efficient labor. Against these conditions, the American mines are seriously handicapped by their very low-grade ore (¼ to ½ per cent.) and high labor costs. Under the circumstances, it is doubtful if any American production of importance can be made under $50 per flask, and probably not much at less than $60.

The world's production of quicksilver today is about two-thirds of normal, based upon the pre-war figures. Consumption at the moment is even lower, owing to the general business depression and the absence of demand from Germany, once a large consumer. Any general increased demand can be supplied by the Italian mines.

Marketing of Foreign Quicksilver.[1]—The non-renewal by the Spanish Government of the contract whereby Rothschild's held the monopoly for the sale of the quicksilver from the famous Almaden mines may have interesting developments. At one time Spain was only too glad to borrow from the banking house in question, and as the result of Rothschild's monopoly, the quicksilver market was centered in London.

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In Spanish official circles there seems a tendency now to favor an "entente" between the Spanish and the Italian mines. Italy, by recovering Trieste and Carniola, has gained the former Austrian State mines of Idria, which together with the Monte Amiata deposits in Tuscany, give her first place today among the world's producers. There is competition between Spain and Italy.

Spanish ore is of comparatively high average content, and this of course should be an advantage, although perhaps the Spanish administration has not been sufficiently capable to make full use of it. Export sales are certainly handicapped by the high exchange rate of the peseta. The Italian ore is of low average content, and extraction is therefore more difficult, but the Italian producers are reported to enjoy plentiful labor and to have well-equipped plants, while of course the low state of the lira is in their favor.

In some quarters it is believed that a European quicksilver trust may ultimately be formed, of which possibly Rothschild's sales organization would form the pivot, although some entirely new arrangements might be made for handling the Spanish output. The fact that the mines in question are national properties may retard the formation of such a trust, but in view of the fact that the two competing groups find operations unprofitable, it would seem inevitable that they must eventually come to a mutual agreement.

The formation of such a trust would be a serious menace to the miners of the United States, for without the barrier of the tariff, the trust would be able to sell at prices with which no mine in this country can compete. As quicksilver is an absolute essential in the manufacture of munitions of war, any country which in the future should aspire to disturb the peace would do well to form an alliance with the quicksilver-producing countries.

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RADIUM[1]

By Richard B. Moore

Notwithstanding the fact that the demand for radium in 1921 was not nearly so strong as in 1920, the production in 1921 was slightly greater than in 1920. The total amount of radium produced in the United States last year was 36 grams, calculated as element. This production was divided among six companies, namely, The Standard Chemical Co., of Pittsburgh, Pa., The Radium Co. of Colorado, Denver, Colo., the U. S. Radium Corporation, of New York and Orange, N. J., the W. L. Cummings Chemical Co., of Lansdowne, Pa., the Keystone Metals Reduction Co., of Cheswick, Pa., and the Carnotite Reduction Co., of Chicago, Ill. The latter company, although it went out of business some time ago, produced some radium in its cleaning-up operations. This makes a total production in the United States up to date of approximately 151 grams of radium element. Allowing 40 grams as the approximate production abroad up to the end of 1921, the world's production of radium has been approximately 190 grams. This means that during the last year nearly as much radium was produced in the United States as the rest of the world has supplied since the discovery of radium up to the present time.

No pitchblende was mined in this country during 1921: all of the production came from carnotite.

A new company produced some radium during 1921, namely the Keystone Metals Reduction Co., of Cheswick, Pa. The old plant of the National Radium Institute in Denver, under the control of W. A. J. Bell, was operated to some extent on a coöperative basis with one of the other companies.

Technology

No radical changes in technology were developed during 1921. In general, the methods used were the same, namely, acid leach, alkali leach, or alkali fusion. There was, however, more of a tendency to using sliming methods than previously. If carnotite ore ground to 30 or 40 mesh is agitated with water, and then allowed to settle, the heavy silica grains settle to the bottom first, and if the supernatant liquor carrying in suspension the very fine material present in the ore is slimed off, most of the carnotite carrying the radium, uranium, and vanadium goes over with the liquor. A concentrate can be obtained in this way, and the concentrate is then available for treatment by any of the above

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methods. Sometimes the ore is treated chemically before sliming. This usually involves treatment with hydrochloric acid, sulphuric acid, or both. No attempt is made at actual solution of the radium under such circumstances, the radium being left in an insoluble condition, and going over with the fine material when the latter is separated from the coarser silica by sliming. The treatment, when used, however, puts the uranium and more or less of the vanadium into solution, and a separation of the uranium and vanadium from the rest of the ore is thus made during the first step of the process.

There are some advantages in this method, and some disadvantages. The recovery is fair, and a wide variety of ores can be treated by the method. On the other hand, a very crude concentrate is obtained, which has to be more or less treated in the same way as a high-grade ore. In addition, very finely ground ore cannot be treated by sliming methods as the silica does not separate out as described above.

A typical process involving sliming is described by d'Aguiar in *Chemical and Metallurgical Engineering* of Nov. 2, 1921. According to this method, crude ore is sent to the dissolving tanks. These tanks are acid-proof, and good service is given by tanks constructed of acid-proof brick. The ore is spread in a layer from 4 to 6 in. deep on the bottom of the tanks, and is then wet down carefully with water or weak vanadium-uranium liquor from previous extractions. So prepared, the ore is ready for the extraction of the uranium, vanadium, and radium. This is accomplished by treating the ore with the amount of hydrochloric acid necessary to dissolve all values as computed from the chemical analysis and the number of pounds of ore placed in the tank. During the addition of the hydrochloric acid, the ore is continually turned and agitated so that the acid may act evenly on the entire mass. Sulphuric acid is then added in sufficient quantity to precipitate all barium and calcium. Water or more weak vanadium liquor from previous extractions is then added. The liquor, which now contains the uranium and vanadium in solution, and the barium-radium sulphate in suspension, is removed by decantation through an opening in the side of the tank at a height flush with the top of the bed of sand tails. The bed of sand remaining in the tank is washed with water or more weak vanadium liquor, and is again stirred to remove any sulphates. The liquor first decanted and the first wash-waters go to a storage tank, while the second wash-waters, being weaker in radium values, are used for first washes on new lots of ore, the sulphates accumulating in this tank being periodically cleaned up and combined with other lots of sulphates.

The sand tails before being conveyed to the dump are carefully sampled, and a sample is sent to the electroscopic laboratory for analysis.

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The liquor and sulphates in the first storage tank are siphoned or pumped to a wooden frame filter-press. The vanadium-uranium liquor passing through as filtrate is pumped to storage tanks.

When the press cake has been washed, the press is stripped and the cake sampled and weighed. These crude sulphates are transferred to pressure-kettles where water and a calculated excess of sodium carbonate are added, and the mass is "cooked" under steam pressure until the barium sulphate, together with the radium sulphate, is converted to the carbonate, with formation of an equivalent amount of sodium sulphate.

The contents of the pressure-kettles are than pumped through iron frame filter-presses. The sodium-sulphate liquor, containing the excess unchanged sodium carbonate, is run to the sewer. The radium-barium carbonate is dropped from the presses, sampled, and weighed. It is dissolved in a tank with dilute, sulphate-free hydrochloric acid, and from that point on is treated in the ordinary way.

Foreign Production

The well-known mines at St. Joachimsthal have now passed into the hands of the Czecho-Slovakia Republic. The annual quantity of radium produced amounts to about two grams. It is stated that as the earnings from the radium mines of the Republic are looked upon as a possible source of much profit to the Government, a project is under way for considerable improvements for both the mining and treatment of the ore. An arrangement has been made with an English Corporation to handle the radium, so that a steady market is thus obtained for the radium produced. Radium is also being produced in France and in England.

Since the exportation of carnotite ore from this country has practically ceased, the French largely use the autunite ores from Portugal, and the British use pitchblende from the Cornish mines. The production of ore from these mines in the last few years, however, has been small.

Uses

The principal use for radium is still in connection with cancer treatment. The larger part of the radium sold today is for this purpose, and a relatively small amount goes into luminous paint, which for many years represented the principal demand for radium. Encouraging results are being obtained in connection with cancer treatment, and the technique is being steadily improved. There are a number of places in the United States today where quite considerable quantities of radium are available for therapeutic use, although a considerable amount of the annual production still goes to physicians all over the country in small amounts.

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Some work has been done during the year in connection with the coloring of precious stones by means of the rays from radium. The Bureau of Mines Station at Reno has done some work along this line with interesting but rather erratic results. Some of the stones have been greatly improved in color; off-color diamonds have been given a grass-green color, thus improving their market value, but in other cases carbon spots developed in the stone with a consequent decrease in value. This work is being further continued.

PRICES

The prices during the past year have been practically the same as in 1920. The average price for radium in small quantities has been from $110 to $120 a milligram for radium element. On large sales, where bids have been obtained, the price has usually been less than the above figures.

MESOTHORIUM

The manufacture of mesothorium was continued during the year by two companies. A large part of the production, however, came from accumulated stocks of concentrates, and not from the treatment of fresh ore. The demand for mesothorium has been steady, and the prices ranged around $60 for an amount equivalent in activity to one milligram of radium element.

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SELENIUM AND TELLURIUM

By S. Skowronski

Selenium has finally found its field of usefulness in the glass industry, which is gradually absorbing the entire output of various copper refineries. The year 1921 was notable for the large export shipments of selenium, the glass manufacturers abroad beginning to use selenium on a large scale. While selenium is still being used in the manufacture of "ruby" glass, the chief function of selenium in the glass industry is that of a decolorizer, to offset the green color of the glass due to iron.

The production of selenium in the United States in 1920 was 92,141 lb., valued at approximately $175,508. This represents an increase of 53 per cent. in quantity and 39 per cent. in value over the 1919 figures. Selenium and selenium salts imported in 1921 amounted to 1106 lb. valued at $2099. None was imported in 1920, but in 1919 the imports were valued at $25,866. This amount has not been approached in other recent years. The amounts exported are not reported.

Data on the production of tellurium are not available for publication. The amounts imported and exported have been too small to be reported by the Department of Commerce.

During 1921 the quoted prices for selenium (amorphous powder) were $2 to $2.25 per lb., but these quotations are largely nominal. Early in 1922 selenium was quoted in London at 7s. 9d. per lb., and tellurium at 40s. per lb.

Use of Selenium as a Decolorizer for Glass.—Prof. W. E. S. Turner in reading a paper by Mr. A. Cousen and himself, entitled "Some Notes on the Production of Colorless Glass in Tank Furnaces," before the Society of Glass Technology on Mar. 15, 1922, at Stourbridge, England, said:

> Selenium, generally in the elementary form, and accompanied by cobalt oxide and arsenious oxide, is now commonly used for decolorizing. The conditions governing its successful use are not clear, particularly when saltcake is present in the batch. To elucidate these conditions, Mr. Cousen had made a series of melts, and found that the normal bottle-glass batch (sand 1000, limespar 200, soda ash 370 parts) could be decolorized with ½ oz. of selenium and 1/12 oz. of cobalt oxide per 1000 lb. of sand when melted at 1375° C. for 3½ hr. If 10 parts of soda ash were replaced by an equivalent weight of saltcake, twice as much selenium was needed, and even four

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times the amount did not prove excessive, and if 20 and 40 parts of soda ash were replaced, 2 oz. of selenium per 1000 lb. of sand gave good results. The effect was partly due to the solution of iron compounds from the pot by saltcake and partly to the reaction between saltcake and selenium. For successful decolorisation the amount of iron in the glass should not exceed about 0.11 per cent. as ferric oxide. Much less selenium was required for a soda-ash batch if it were introduced as sodium selenite, as the tendency to burn out was checked.

The Electrical Application of Selenium.—The present-day development of the wireless telephone has held back the commercial use of selenium cells, which formerly was being experimented with by the telegraph companies. It is unfortunate that this one unique property of selenium, that of being the only metal to vary its electrical conductivity with the intensity of light, has never attained the commercial possibilities which it gave promise of reaching years ago.

In 1873, Inspector May, an assistant of Willoughby-Smith at the Valentia Island Cable Station off the coast of Ireland, made the observation that the electrical conductivity of selenium varied with the intensity of the light, and in reporting their phenomena Willoughby-Smith wrote: "By means of a telephone, I can hear a ray of light falling upon a metal plate."

Werner Siemens made selenium cells in 1875. In 1878 Graham Bell, the inventor of the telephone, prepared selenium cells and in conjunction with Sumner Tainter experimented with a photophonic receiver which enabled them to transmit communications by wireless telephone to a distance of several hundred feet.

This important property of selenium, *viz.*, the variation of its electrical conductivity with intensity of light, made the metal at once a subject of interest and a source of experiments to those interested in electrical work. Many types of selenium cells have since been devised, developed, and experimented with for commercial purposes.

The basic principle of these selenium cells is the same in all types, and depends upon a conducting metal such as copper, brass, platinum, silver, gold, etc., in the form of plates insulated from each other by means of mica or other insulating material, covered with a very thin film of selenium, or sometimes two wires of conducting material are wound very closely upon a cylinder of non-conducting material (glass) and covered with a thin film of selenium.

The selenium being a non-conductor in the dark acts as an insulator and does not permit any of the current applied to the cell to be transmitted, but on exposure to light the conductivity of the cell is proportional to the intensity of the light thrown upon it.

Only the crystalline modification of selenium is sensitive to light and

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a cell after being manufactured must be carefully annealed to convert the selenium covering the cell into this crystalline modification.

The connecting of selenium cells by means of "relays" and other electrical apparatus to mechanical appliances permits of some novel and interesting commercial uses.

The following are some of the electrical apparatuses made possible by selenium cells:

Photophone: Bell's original invention making it possible to "hear a shadow" by means of a telephone; of historic interest only.

Phototelegraph: Apparatus designed to transmit photographs or sketches along a wire; has possibilities, but was never perfected.

Photographophone: Apparatus for making synchronous records of sounds with moving pictures.

Optophone: A new apparatus invented by Fournier D'Albé in 1914 whereby the blind may read ordinary type by ear.

Self-lighting buoy: Apparatus whereby buoys and beacons in inaccessible spots may automatically light and extinguish themselves, depending upon the sunlight.

Photometers: To measure the intensity of light.

Control of draft in factory chimneys: Recording device set in chimney will vary in proportion to the smoke.

Control of progress of the manufacture of sulphuric acid: Apparatus to detect the presence of vapors in the contact process for the manufacture of sulphuric acid.

During the war, the French Government made a special study of selenium cells for their application to military arts, a few of the uses being:

Wireless telephony: Tried and given up owing to the limited range possible.

Telemechanics: The locating of enemy batteries by light, and the detection of range by sound.

Very little pioneer work on selenium cells has been done in this country, nearly all of the work mentioned above having been accomplished in European countries. None of the uses of selenium cells mentioned above has as yet been developed into a commercial success for the reason that the selenium cells themselves have not been thoroughly successful.

The manufacture of commercial selenium cells is still in the course of development, and while many commercial uses have been suggested and the possibilities are great, they depend on perfect and uniform cells, which up to this time do not seem to have been made commercially.

As mentioned before, only a thin veneer of selenium is needed for a cell, the thinner the better to overcome inertia, and 1 lb. of selenium will

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make from 200 to 300 cells, so it can be seen that even if the art of manufacture of selenium cells be perfected, the tonnage of selenium consumed for that purpose will never be large and copper refiners must look to other uses for disposal of their selenium output.

New Uses of Selenium and Tellurium.—The commercial possibilities of selenium oxychloride are being developed by Dr. Victor Lenher, and a systematic study is being made of the chemical properties and reactions of this active chemical compound. The University of Wisconsin has become a mecca for the study of selenium and tellurium, and in 1921 twenty-two graduate students were doing research work on these elements at that university.

An interesting use for selenium has been patented by Thomas A. Edison.[1] "A metal, *e.g.* copper, nickel, or iron, is provided with a surface-coating of selenide by immersion in selenious acid; if the metal thus coated is electroplated with nickel, copper, iron, silver, etc., the plating can afterward be easily stripped off without defacing the surface even when this is marked with delicate figures or designs."

During 1921 marked progress has been made in the development of the possibilities of the commercial uses of tellurium. In common with many other substances, tellurium has been found to work admirably as a crystal detector in radio work. The sale of tellurium for that purpose has been large and while the rapid development of the wireless industry forbids any prophecy as to the future of tellurium for that purpose, it is interesting to note that this is the first technical use of tellurium on a commercial scale.

A potential use for tellurium which has the possibility of using the entire output of tellurium is the discovery of Messrs. Thomas Midgley and Thomas Boyd, of the General Motors Research Corporation, that the addition of one part by weight of di-ethyl telluride in 10,000 parts of gasoline increases the efficiency of the internal combustion engine by 20 per cent. This remarkable discovery was made during the investigation of anti-knock compounds for automobile engines, the effect of tellurium for that purpose being almost magical.

Messrs. Midgley and Boyd using di-ethyl telluride in a specially constructed automobile engine have been able to obtain an increased mileage efficiency of 100 per cent., the principle being that in a special type of motor using "tellurized gasoline" it is possible to increase the compression, which necessitates altering the gear-ratio and by this means increasing the efficiency. It has been calculated that in order to "tellurize" the gasoline used in the automotive industry, 1500 tons of tellurium a year would be required, while a careful survey of the

[1] U. S. Pat. No. 1,359,972.

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entire output of the copper and lead refineries gave a maximum production of only 90 tons of tellurium a year. As the increased efficiency is dependent upon a new type of motor the construction of which is not practical unless a much larger supply of tellurium is available, the invention is not as yet being developed commercially.

This problem has stimulated the search for tellurium ores, as it is now realized that the ores may be of value for their tellurium contents. It would seem that even if the quantity of tellurium available is not sufficient to warrant the application of this invention to the automobile industry, there is nevertheless an important field for this invention in the development of the airplane industry.

Tellurium has been experimented with in high-resistance alloys. According to Matthiesen, tellurium has the highest resistivity of any of the so-called metallic elements, its resistivity being 200,000 microhms per centimeter cube. Since copper has a resistivity of 1.7, the conductivity of tellurium is 0.00085 per cent. of that of copper.

A solution of tellurium in acids has a limited use in the jewelry industry as a dip for silver articles, giving a finish on the metal which was formerly obtained by dipping in a platinum solution.

A solution of tellurium oxide in hydrochloric acid is used to mark numbers on the inner stems of electric light bulbs. The action of heat reduces the tellurium to metal, which remains permanently on the glass.

The *Journal of Industrial and Engineering Chemistry* for June, 1920, reprints a report by Victor Lenher, presented at the April meeting of the American Chemical Society, in which he reviews the present uses of selenium and tellurium and discusses the possibility of increasing their consumption.

A recent estimate of the amount that can be produced in the United States, without making any material additions to the present plants, has shown that the United States can furnish more than 300,000 lb. of selenium and about 125,000 lb. of tellurium annually, figures far beyond the actual consumption. This product comes entirely from electrolytic copper refineries. The substances are commonly marketed in elemental form, although some of the refineries have produced small quantities of derivatives such as sodium selenite and tellurium dioxide.

The chemical characteristics of these two elements closely follow those of sulphur; indeed, the types of selenium and tellurium compounds are in general those of sulphur, but owing to their higher atomic weights they are more metallic. Tellurium in elemental form looks much like antimony. It is white and so strongly crystalline that it is quite brittle and can be easily powdered. Toward acids it is as refractory as antimony. Toward alkaline solutions it is strongly resistant, while in water or in moist air it does not rust or corrode appreciably. It is known that antimony can be used in electroplating and gives a durable plating. It would be interesting to study tellurium in this direction. A systematic study of the available electrolytes that can hold tellurium in solution could be carried out advantageously. Antimony

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has been successfully used for many years in anti-friction alloys and is an essential constituent of stereotype metal. No recorded study is known of an attempt to utilize these alloys, but the whole field of the metallic alloys of tellurium needs to be studied carefully, and unquestionably an element whose general characteristics are so close to antimony will be found a useful metal instead of having no practical applications. Another metallurgical line which has not been studied in any detail is the action of these two elements in the iron and steel industry. The effect of sulphur and phosphorus on iron and steel have been carefully studied. It is interesting to contemplate what careful experimentation might develop on the influence of selenium and tellurium on the various grades of steel.

It has been known for a long time that selenium gives a red color to glass. During the war this principle was made use of in decolorizing glass on account of the shortage of manganese, the color being used to counteract the green due to iron content. Selenium is introduced into the glass either in the elemental form or as a salt. As the rose color which it imparts is not exactly the complement of the green of ferrous iron, it is common practice to add a small amount of cobalt oxide along with the selenium.

A number of possible uses for these elements suggest themselves, none of which have received the attention that they deserve. Lithopone, the intimate mixture of barium sulphate and zinc sulphide made by bringing together barium sulphide and zinc sulphate, is full of suggestions. Various colored lithopones can be produced by using an antimony-sulphate liquor with barium sulphide, when the white barium sulphate is colored by the orange sulphide of antimony. Similarly, cadmium or arsenic liquors give a corresponding yellow lithopone. The substitution of selenium and tellurium is very suggestive, inasmuch as it should be possible to replace the sulphur of either the sulphate or the sulphide by either of these elements. The selenate and tellurate of barium are white and insoluble like the sulphate, while the selenides and tellurides like many of the metallic sulphides are variously colored.

The use of the various compounds of selenium in medicine has received some attention, but the derivatives have had almost no systematic study. In a very careful study Prof. W. J. Gies, of Columbia University, has shown that tellurium compounds have a physiological action similar to that of arsenic, but that their toxicity is much less. The selenides and tellurides as well as the oxidized salts have been experimented with in cancer, tumors, and syphilis, but their efficacy is more or less questionable. These few compounds which are of the simplest chemical character are almost the only ones of which any experimental results are recorded. When one considers the vast field of important and valuable sulphur-containing medicinals ranging from saccharine to sulphur itself and in the arsenical, from Fowler's solution to salvarsan, it would seem that there exists an almost entirely new field for research by the physiological chemist. The offensive garlic odor of the "tellurium breath" will unquestionably act as a deterrent in the minds of some, but should certain physiological actions be found, they might be so valuable as to overcome the objections due to the characteristic methyl-telluride odor.

In the vulcanization of rubber a few experiments are recorded which seem to indicate the similarity of the action of selenium to that of sulphur. Much remains to be done, especially along the lines of the use of the chlorides or bromides of these elements as accelerators. Tellurium and its derivatives have received practically no attention in the rubber industry. Possibly from the nature of the organic materials present, the objectionable methyl telluride would again militate against its use.

A relatively small amount of research has been conducted with selenium in the dye industry, while nothing has been done along these lines with tellurium. One of

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the first applications which would naturally occur would be the substitution of selenium for sulphur in the so-called sulphur colors, which are among the cheapest colors. There are at present two serious obstacles in the replacement of sulphur by selenium. The first is the relative cost of the selenium. The second is the nature of the bath which, in the present development of the sulphur color process, would make the cost prohibitive. There is, however, the possibility that there might be found a brilliant and fast color of considerable intensity which could be manufactured profitably. The field of synthetic dye stuffs possesses great opportunities for experiment and is almost undeveloped.

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poorly or not at all upon starch and cellulosic materials. With linseed oil and fish oil, $SeOCl_2$ yields products which are waterproof and rubber-like in character and with other oils various products suitable for use as *substitutes for rubber* and *resins* are obtained, the products generally being insoluble in ordinary solvents. It may also be used in the same manner as CCl_4 as a *fire-extinguisher*. It is soluble in both CCl_4 and $CHCl_3$. These two substances may be added to $SeOCl_2$ to lessen its powerful solvent action. SO_2 increases the solvent power of $SeOCl_2$ when added to it.

NISHIMURA, K.—Separation of Tellurium or Selenium from Compounds or Mixtures by Electrolysis. Jap. Pat. No. 38,085.

SHIONI, T. and OZU, K.—Recovery of Selenium from Copper Slimes. Jap. Pat. No. 36,929.

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SODIUM SALTS

By Alan G. Wikoff

The production of natural sodium compounds in the United States in 1921 amounted to 25,000 short tons valued at $894,000, according to reports of the producers to the United States Geological Survey. This was a decrease of about 41 per cent. in both quantity and value. The material marketed was sodium carbonate (soda ash) from Cartago and Keeler, Inyo County, Calif.; sodium bicarbonate from Keeler, Inyo County, Calif.; sodium sulphate (Glauber's salt) from Lake Point, Salt Lake County, Utah, and Casper, Natrona County, Wyo.; sodium borate (borax) from Trona, San Bernardino County, Calif.; and trona (a double salt of sodium carbonate and sodium bicarbonate) from Trona, San Bernardino County, Calif.

SODIUM COMPOUNDS SOLD IN THE UNITED STATES
(In short tons)

Product.	1919. Quantity.	1919. Value.	1920. Quantity.	1920. Value.
Sodium acetate	778	$116,667	1,020	$143,887
Sodium benzoate	126	230,224	201	365,841
Sodium bicarbonate	134,962	3,486,635	188,906	4,256,715
Sodium bichromate	26,526	6,233,566	25,973	5,531,954
Sodium bisulphite	11,819	687,750	22,059	1,028,373
Sodium bromide	499	493,319	543	523,724
Sodium carbonate:				
Soda ash	981,054	29,895,343	1,242,490	39,083,726
Monohydrate	30,796	710,748	12,267	115,256
Trona			0,609	343,911
Sal soda	80,090	2,229,994	62,857	2,128,937
Sodium chloride (common salt)				
Salt in brine	2,850,639	1,423,424	2,819,881	1,834,362
Rock salt	1,642,057	6,240,450	1,683,020	7,338,079
Evaporated salt	2,390,306	19,410,820	2,444,002	21,334,840
Sodium citrate, tartrate, and bi-tartrate	33	58,128	45	67,115
Sodium ferrocyanide	3,437	1,346,285	2,930	1,318,049
Sodium fluoride and acid fluoride	(a)	(a)	934	210,782
Sodium fluosilicate	(a)	(a)	719	143,800
Sodium hydroxide	311,388	20,091,978	382,680	25,894,641
Sodium iodide	12	86,985	10	29,905
Sodium nitrite	676	151,621	140	56,184
Sodium phosphate	14,760	1,733,996	30,515	3,233,896
Sodium silicate	300,138	5,879,628	304,503	5,751,088
Sodium cyanide, peroxide and nitrate (refined)	17,188	5,331,123	8,633	3,415,085
Sodium sulphate:				
Salt cake	134,685	2,035,543	184,946	2,076,350
Glauber's salt	42,087	860,977	44,479	963,293
Niter cake	83,402	271,424	308,638	788,544
Sodium sulphide	45,448	2,645,181	42,952	2,962,033
Sodium sulphite	(b)	(b)	3,778	197,782
Sodium tetraborate	28,518	4,351,891	35,281	5,674,012
Sodium thiosulphate	32,212	1,709,223	24,868	1,283,697
Other sodium compounds	2,190	1,144,883	6,141	1,240,477
	9,105,726	$118,857,806	9,886,920	$139,336,338

(a) Included in other sodium compounds.
(b) Included in sodium bisulphite.

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Sodium Nitrate

During 1921 the Chilean nitrate industry experienced the most serious crisis which the industry has ever known. Stocks of nitrate which should have been sold in the fall and winter of 1920 remained in the warehouses as a result of the general depression in nitrate-consuming fields, so that the year opened with a visible supply estimated at 2,241,000 long tons (of which 1,340,000 tons was in stock in Chile).

Confronted with the possibility of an indefinite continuation of lack of demand, European holders of large stocks of nitrate federated in February, 1921, in order to protect themselves from disaster. This organization, which came to be known as the "pool," combined sales and the conduct of its affairs under the leadership of the firm of Antony Gibbs & Sons, of London, the most important associate and the one which had dealt in Chilean nitrate for 40 years. The Association of Nitrate Producers had already been induced, through representations of the independent purchasers and of important British banking interests which were concerned with the financing of the purchases of nitrate, to fix on Jan. 26, 1921, a price of 17s. per Spanish quintal (101.4 lb.), to be effective until June 30, 1921, and to declare that for 10 months thereafter the price would not be lower than 14s. Following the organization of the pool, the subsequent negotiations, necessitated by the dangers foreseen and feared by both the pool and the association, were conducted by these two organizations, formed respectively of the marketers and of the producers of Chilean nitrate. It became apparent that some sort of formal understanding would have to be reached between these bodies in order to help the return of the industry to a normal basis without bringing upon either one a catastrophe which would react disastrously upon the other.

The strong position of the pool, composed of the firms with the greatest experience in the business and with the organization necessary to conduct distribution, was a factor which could not be overlooked by the association. The heavy obligations of the pool to the Producers' Association also called for the co-operation of the latter in protection of its own interests. The moderate shipments on old orders, which proceeded during the first half of 1921, promised to leave about 5,000,000 Spanish quintals still unshipped at the end of June—a consideration which influenced both sides, as the necessity of taking up this quantity made it desirable for the pool to retain the monopoly until it could be disposed of, while the association wished to put no obstacle in the way of the realization of and remuneration for this final delivery. Another motive for co-operative action was also found in the possibility that the

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Government of Chile, if an absolute deadlock was reached, would insist on intervention in the industry and would make arrangements for the shipments of stocks on consignment to governments or other interests in Europe which had made advances to that end. For these reasons there was a feeling of mutual dependence on the part of the pool and this association, which pointed to the necessity of an agreement. Such agreement could mean but one thing—that a certain loss must be faced in disposing of present stocks. How this loss should be divided became the question.

Preliminary discussion about this point began in April and the following agreement was finally made Oct. 11, 1921:

1. The prices fixed by the Association on June 30 in accordance with the resolution of Jan. 26 of this year are hereby corrected.

2. The revision in prices shall consist in establishing the following scale to go into effect from date to June 30, 1922. October, 10s. 6d.; November to April, 1922, inclusive, 11s.; May, 1922, 10s. 9d.; June, 10s. 3d. Beginning July 1, 1922, the Association may fix whatever prices it deems convenient to its interest.

3. The pool declares its acceptance of the revision of prices established under the previous articles.

4. The Association shall pay the pool under this agreement the following compensations: (*a*) For all and any quantity of new nitrate that may be sold for delivery between Oct. 1, 1921, and Mar. 31, 1922, and which has been actually shipped before this last date, 20d. per Spanish quintal; (*b*) for all and any quantity of new nitrate sold for delivery between Apr. 1, 1922, and June 30, 1922, and actually shipped before this last date, 12d. per Spanish quintal; (*c*) all new nitrate sold for delivery between July 1, 1922, and June 30, 1923, and actually shipped before this last date, 4d. per Spanish quintal.

5. The total amount of the compensation referred to in the above paragraph shall be distributed among the members of the pool in the proportion and manner the President of Chile shall consider advisable. (This distribution was later fixed at 82.4 per cent. for the pool and 17.6 per cent. for other buyers.)

6. The Association guarantees to the pool as a minimum compensation the sum of £1,500,000, and in case the payment of that sum has not been completed by the Association by June 30, 1923, it shall continue paying the pool 4d. per Spanish quintal sold, until said sum of £1,500,000 has been paid up.

7. The payment of the compensation quotas shall be made directly by the Association at the time of receiving payment for the nitrate sold.

8. In the event that the Association should consider advisable to sell through consignees, the price paid shall be based upon the scale fixed under paragraph 2 until June 30, 1922. The contracting parties are agreed that the President of Chile shall appoint the arbitration body should any misunderstanding arise.

Concurrently with this the pool reduced its selling prices in Europe to the parity of about £13 10s. for spot delivery, rising to about £14 10s. for March—April 1922, and the moderation of these limits—about £9

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per ton below those which were asked in October, 1920—together with at least the promise of a foundation on which the market could more firmly rest, made an immediate appeal to inland buyers, who supplied themselves freely during the month of October in anticipation of their spring requirements.

Improvement was not very general, however, and the year closed with about 1,600,000 tons available for the world's consumption during the current nitrate year to June 30, 1922—and this in spite of greatly restricted production during the year. On Jan. 1, 1921, 101 oficinas were in operation, the number decreasing to 66 on Apr. 1, 41 on June 30, while at the end of the year only 34 were working, with a production of about 70,000 tons per month.

In spite of the increase in the price of synthetic nitrogen products in Germany after the Oppau disaster, Chilean nitrate is still unable to compete at the present rate of exchange.

In view of developments during the year the following information regarding the Association of Nitrate Producers is of interest:

The present association was organized in January, 1919, for a term of five years, which may be prolonged for equal periods according to the will of the members.

In December, 1920, the three German producing companies—H. B. Sloman & Co. (now the Tocopilla Nitrate Co.), Gildemeister & Co., and the Cia. Salitrera Alemana—entered the association, leaving outside it only one small Chilean company and two American producers—the Grace Nitrate Co. and the DuPont Nitrate Co. The present membership of the organization is composed of 79 firms, operating 150 oficinas, of which only a few are in process of construction or not in a condition to operate. The total productive capacity of the association is placed at 86,877,600 Spanish quintals, or 96 per cent. of the total. The two American firms, operating three oficinas, with the one independent Chilean company, are estimated to have a production of 3,540,000 quintals, or 4 per cent. of the total potential production of the industry at present, which is calculated at 90,417,600 quintals.

The total production of Chilean nitrate in the year 1920–21 amounted to 47,263,030 Spanish quintals, as compared with 42,549,379 quintals in the year 1919–20. The production of 1920–21 was therefore greater by 4,713,651 quintals than that of the preceding year. The amount exported in 1920–21 was 44,581,079 Spanish quintals, or 3,396,404 quintals less than the exports of 1919–20, which amounted to 47,977,483 quintals.

Association figures showing the quantity of sales for the 1920–21 nitrate year and the period from Jan. 1, 1919, to June 30, 1920, are as follows:

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SALES OF CHILEAN NITRATE
(In quintals of 101.43 lb.)

Kinds of Nitrate.	Jan. 1, 1919, to June 30, 1920.	For Delivery from July 1, 1920, to June 30, 1921.
Nitrate of soda:		
95 per cent. (ordinary)	35,420,801	33,803,760
96 per cent. (refined)	1,244,508	230,041
Nitrate of potash	800,897	738,900
Total	37,466,206	34,772,701

Production and shipments during the calendar years 1920 and 1921 are compared in the following table:

	1920, Long Tons.	1921, Long Tons.
Production	2,463,200	1,280,250
Shipments:		
To Europe	1,300,800	640,650
To United States	1,237,550	372,400
To other parts	194,950	76,000
Total	2,733,300	1,089,050

In the face of low price-levels, weak demand, competition from synthetic nitrogen products and the necessity of working caliche of lower and lower grade, immediate attention to all possible means of reducing costs seems imperative for the maintenance of the industry on a sound economic basis. Technology will merit special consideration, since it has been estimated that a 40-per cent. reduction in cost should be possible through improved processes. Better recovery, more efficient fuel utilization, and improved mining methods are problems which, when solved, will do much to decrease the cost of production. In many of the plants at present 30 to 33 per cent. of the total cost of the finished nitrate at the plant is charged to fuel, while placing the ore at the plant accounts for 45 per cent. more.

United States Imports of Nitrate.—The imports of Chile saltpeter into the United States over a period of 9 years, as shown by the Government records, were as follows:

	Long Tons.	Value.	Price per Ton.
1913	625,862	$21,630,811	$34.54
1914	541,715	15,228,671	28.22
1915	772,190	22,959,997	29.73
1916	1,218,423	38,131,962	31.30
1917	1,543,213	60,437,526	39.16
1918	1,845,074	90,360,207	48.97
1919	407,459	19,558,963	48.00
1920	1,321,892	63,121,035	47.75
1921	369,173	17,982,977	48.71

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SALT

United States.—Revised figures for 1920 give the quantity of salt produced and sold in the United States as 6,840,029 short tons, valued at $29,894,075, a decrease of 42,873 tons but an increase of nearly $3,000,000 over 1919.

PRODUCTION OF SALT IN THE UNITED STATES (a)
(In barrels of 280 lb.)

Year.	California.	Kansas.	Louisiana.	Michigan. (c)	Nevada.	New York. (c)	Ohio and W. Virginia.	Texas.	Utah.	Other States.	Total, Barrels
1910	937,514	2,811,448	1,372,248	9,452,022	17,535	10,270,272	3,829,475	382,164	249,850	983,128	30,305,656
1911	1,086,163	2,159,859	(d)	10,320,074	12,856	10,082,656	4,485,886	385,200	272,420	2,391,710	31,196,824
1912	1,090,000	2,573,626	(d)	10,946,739	12,536	10,502,214	5,408,300	373,064	283,293	2,135,036	33,324,808
1913	1,082,993	2,698,079	(d)	11,528,800	8,971	10,819,521	5,424,056	355,529	330,443	2,189,913	34,438,305
1914	(d)	2,967,864	(d)	11,670,976	4,436	10,389,314	5,628,265	433,979	375,457	2,332,649	34,804,683
1915	1,048,457	3,765,164	(d)	12,588,788	6,929	11,217,471	6,112,482	444,978	394,850	2,652,377	38,231,496
1916	1,124,236	4,564,793	(d)	14,918,278	(d)	14,087,750	6,706,193	541,157	433,236	2,834,880	45,449,323
1917	1,536,814	5,335,543	(d)	16,078,136	(d)	15,457,636	7,511,764	608,436	565,679	2,750,114	49,844,121
1918	1,463,979	5,853,600	(d)	17,165,179	693	15,218,071	7,971,172	568,978	672,886	2,748,787	51,705,317
1919	1,429,393	5,525,543	(d)	17,802,700	(d)	13,913,064	7,216,636	(d)	552,400	2,723,850	49,163,586
1920	1,514,343	5,597,536	1,893,464	16,163 677	(d)	13,593,580	7,768,600	650,736	537,564	1,137,850	48,857,350

(a) Statistics of the U. S. Geol. Surv. (c) Includes brine used in manufacture of alkali. (d) Included in "Other States."

CONSUMPTION OF SALT IN THE UNITED STATES
(In tons of 2000 lb.)

Year.	Production.		Imports.		Exports.		Consumption.	
	Amount.	Value.	Amount.	Value.	Amount.	Value.	Amount.	Value.
1906.....	3,944,133	$6,658,350	170,505	$502,583	33,988	$274,627	4,080,650	$6,886,306
1907.....	4,160,729	7,439,551	153,435	452,227	30,802	232,895	4,283,362	7,658,883
1908.....	4,024,345	7,486,894	156,609	440,484	26,627	202,338	4,154,327	7,725,040
1909.....	4,215,070	8,343,831	158,487	447,983	40,158	269,273	4,333,397	8,522,541
1910.....	4,242,792	7,900,344	142,549	388,015	49,013	320,926	4,336,328	7,967,433
1911.....	4,365,756	8,345,692	137,759	378,083	48,873	335,285	4,454,642	8,397,490
1912.....	4,665,473	9,402,772	136,391	361,664	62,410	418,525	4,739,454	9,345,911
1913.....	4,821,368	10,123,129	150,601	416,375	70,289	515,194	4,901,680	10,024,310
1914.....	4,872,656	10,271,358	130,752	385,752	82,295	586,055	4,921,113	10,071,055
1915.....	5,352,409	11,747,686	123,576	366,475	80,474	613,850	5,395,511	11,500,311
1916.....	6,632,906	13,645,947	121,967	342,588	84,065	567,411	6,670,808	13,998,535
1917.....	6,978,177	19,940,442	65,840	280,135	113,993	1,000,773	6,930,024	19,219,804
1918.....	7,238,744	26,940.361	40,316	284,032	136,783	1,677,577	7,142,277	25,546,816
1919.....	6.882,902	27,074,694	62,821	324,402	121,701	1,396,625	6,829,022	26,002,471
1920.....	6,840,029	29,894,075	137,654	676,499	139,272	1,901,593	6,838,411	28,668,981

Underground mining of salt in the coastal salt domes of Louisiana was described by Albert G. Wolf.[1]

The two operating salt mines are at Avery Island and Week's Island, operated, respectively by the Avery Salt Mining Co. and the Myles Salt Co. The surface of the Avery Island dome is about 1½ miles in diameter and rises to a height of over 100 ft. above sea-level, and nearly as much above the surrounding marsh land. The salt, at its highest point, is within 16 ft. of the surface, and although not at the highest point of the hill, it is near enough to bring the top of the salt core above sea-level.

Eng. Min. Jour., 142, 6 (July 2, 1921).

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The surface is largely covered with yellowish or brownish loamy soil, with sand, gravel, and clay in places. The sediments encountered in shallow work are all believed to be Quaternary.

The present shaft was put into operation in 1900. It is of two compartments, vertical, and about 500 ft. deep. The method of mining is simple. After providing for adequate haulageways at the bottom of the shaft, and leaving pillars of proper size to protect the shaft, parallel drifts are extended 60 ft. wide and 60 ft. high (these are probably more properly called rooms). Then half the remaining pillars are removed by driving break-throughs 60 ft. wide, leaving one-quarter of the original area in the form of pillars measuring 60 ft. in all three directions.

The method of advancing the rooms is as follows: First a central drift about 7 by 7 ft. is driven any convenient distance. Then successive sets of slabbing holes are drilled and shot either side of this preliminary drift until the room is undercut its full width and the depth of the holes. As the broken salt is removed, further sets of holes are drilled, until the whole room is undercut. Then the central section above is broken by means of uppers, the first row being drilled just back of the open face of the room and pointing slightly toward it. Work is then continued from the top of the broken salt and from high ladders, and horizontal slices above are shot down until the room has been raised to a height of 60 ft. in the center and a little less at the sides, forming a slightly arched roof. Sufficient salt, of course, is removed all the time to permit the continuance of work. Before clearing the rooms of broken material, the roof and walls are carefully trimmed to remove all loose pieces. The salt, being absolutely dry, will stand indefinitely without sloughing. The break-throughs are driven in the same manner as the rooms.

All this work is carried on without leaving a stick of timber anywhere in the rooms, and when a person, even though acquainted with underground workings of nearly every description, first sees the sparkling, blue and white mottled walls and roofs of this series of immense corridors extending in all directions, absolutely free from support, he is astounded at the operations.

Drilling is done with air-driven augers, and great footages have been made, as much as 100 ft. per hour. Blasting is done with low-grade dynamite, detonated by means of fuse and cap. All shoveling is done by hand on contract, and mule-tramming is employed.

The surface equipment is housed in one large building called the "breaker." It consists essentially of three sections, the engine room, the headframe and crushing plant, and the sacking department. The headframe is about 100 ft. high. Hoisting is done in counter-balance with steam. Single-deck cages are used and the salt is hoisted in mine cars.

The cars are dumped on the top of the breaker over a grizzly and the oversize runs into a large set of toothed rolls. All the salt then passes through a second set of rolls, over coarse screens, and the oversize to a third set of rolls. The material next passes through a series of screens and disc-grinders, where several sizes of salt are made, ranging from table salt to coarse sizes for packing and for ice cream, and having various technical names. The intermediate and medium fine sizes are used, but the very finest is rejected in order to clean the salt, as it carries with it all the powder-stained material. The color of this reject, where it is sluiced out of the mill, is a dark gray.

The process of cleaning is further aided by hand-picking. This is done at the first grizzly and in a traveling belt after the salt has been reduced to about ½-in. size. Foreign particles picked out consist mostly of pieces of powder, burned fuses, and chips of wood from mine cars, ladders, and scaffolds.

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The various sizes of screened salt fall into hopper-bottomed bins, from which the salt is drawn into sacks and weighed. Besides the classes of sized salt, a considerable quantity of rock salt in large lumps is shipped. All of this salt is of high purity.

It is planned to install electrical equipment throughout the mine and mill, which will be much more economical and efficient than the equipment now in use, especially simplifying the mill drive. Mining operations have been carried on for 20 years from one level, and over a million tons of salt has been shipped. The salt core is said to be about 1 mile long and ½ mile wide, and has been drilled to a depth of 2000 ft. without "striking bottom." This would indicate a reserve of approximately 200,000,000 tons. The present management is not worried about next year's supply of "ore."

Week's Island was originally called Grande Côte, because of its size, as it is the largest of this group of domes. The surface of the dome is roughly circular in outline, about 2 miles in diameter, and rising to an extreme height of 120 ft. above sea-level. The strata overlying the salt, as at Avery Island, are all unconsolidated and all belong to the Quaternary. The chief structural difference between this and the Avery dome is that the salt core is somewhat deeper, being 90 to 100 ft. below the surface at the apex of the core. The top of the salt core does not correspond to the topography of the surface, as might be expected, the apex of the core being near the southwest side of the hill, with the steepest slopes to the south and west, and the most gentle to the north.

Mining operations began in April, 1898, when the Myles Salt Co. sank its first shaft. Considerable trouble was experienced in making a "tight seal" between the overlying strata and the salt, on account of quicksand. This seal is absolutely essential in salt mining, to exclude the surface-waters from the salt mass. The methods employed by the Myles Salt Co. are, in general, similar to those used at Avery Island, except that electric power is used for all mining and milling operations other than hoisting. Electric-driven shoveling machines and electric augers and locomotives are used, and the shots are fired by electricity. There is an unaccountable difference between the salts produced at Avery and Week's, the latter being crumbly on exposure, necessitating the shipping of compressed-salt bricks instead of lumps of rock salt, as at Avery Island.

Considering the large number of domes and the immense size of each salt deposit, the actual production of salt from coastal domes is trifling. According to the U. S. Geological Survey, the salt produced in Louisiana and sold amounted to 265,085 tons in 1920, valued at $1,517,414. As equipped, both the Week's and Avery mines are capable of producing 500 tons per day.

There is an immense store of available salt in the domes of Jefferson, Avery and Week's islands, and with the advantages of such large bodies of pure rock salt so close to the surface it is difficult to see why this salt cannot compete with Northern salt over a wider range in the South. Perhaps a comparison of the ratio of cost of production to railroad rates would explain the situation.

Canada.[1]—Of 16 firms normally engaged in the salt industry in

[1] Prelim. Rept. Min. Prod. of Canada, 1921, Dominion Bur. of Statistics.

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Canada 11 reported production for 1921, 9 of these being in Ontario, 1 in Nova Scotia and 1 in Saskatchewan.

The output of salt from all sources during the year amounted to 125,864 short tons, but the sales were in excess of this figure and were given as 127,108 tons valued at $1,641,935, an increase of about $100,000 over the value of sales in the preceding year. The quantity sold was, however, considerably less, the amount sold during 1920 being 209,855 tons. The value of the sales as given above is exclusive of the value of packages sold with the goods. These latter were stated to be worth $639,507. Sales by grades included table and dairy, 40,638 tons; common fine, 36,467 tons; common coarse, 30,107 tons; land salt, 3314 tons; other grades 2989 tons; and the salt equivalent of brine used for chemical works, 13,593 tons.

The principal producing province was Ontario, as already noted. The sales from this province alone amounted to $1,617,876. Less than one thousand dollars' worth of salt was produced in Saskatchewan, but practically the entire output was sold during the year.

The production of rock salt from the Malagash mine in Nova Scotia was carried on throughout the year, and considerable quantities of common coarse salt were produced. Some table and dairy salt as well as land salt and rock salt were also produced.

France.—Consul M. K. Moorhead reported from Nantes that the Guerande salt marshes, in southern Brittany at the mouth of the Loire, consist of 20,000 basins (oeillets) covering an area of about 7410 acres. The total annual production is about 50,000 tons. There is a tax of 10 francs per 100 kilos (220 lb.) on salt exported from the district of production. In recent years prices have ranged from 80 to 90 cts. per 100 lb., rising in 1920 to about $1.15 per 100 lb. Production consists of gray, washed, and refined table salt, and, in addition, a fourth kind as white as snow with a distinct violet odor. On account of its rarity, this salt is much in demand and brings a higher price. Two-thirds of the production is consumed locally, the remainder being sent into the interior of France.

Poland.—Poland has rich salt deposits in the provinces of Galicia and Posen, and in what was formerly Russian Poland. The mine at Wielicka, in Galicia, is one of the largest and best known in the world. About two-thirds of the pre-war production of Polish salt was from Galicia.

At the present time the salt mines are being actively worked. The Polish Government statistics give the output of salt in 1921 as 301,612 metric tons, compared with 245,604 tons in 1920, and representing an increase of 61 per cent. over the 1913 production of 187,097 tons.

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South Australia.—A very thorough report of the salt resources of South Australia has been prepared by R. Lockhart Jack, deputy government geologist.[1]

The State of South Australia is fortunate in that it not only possesses numerous lake salt and gypsum deposits of a magnitude, purity and accessibility unrivaled in Australia, but is so situated climatically that the conditions for solar evaporation, whether from existing saline lakes or from sea-water, are exceptional. Moreover, while the difference between the rainfall and evaporation is considerable, the rainfall during the period of greatest evaporation, from October to March, is very small, averaging only about 25 per cent. of the annual rainfall.

Salt has been gathered on a small scale for strictly local requirements for many years, but it was not until 1891, when 7505 long tons was produced, that the tonnage became notable. The 1919 production was 69,174 long tons valued at £138,348.

The first of the existing companies, the Castle Salt Co-operative Co., was formed in 1898 to take over the salt interests of Henry Berry & Co., and was followed by Commonwealth Salt Refining Co., in 1905; Standard Salt Co., in 1912; Australian Salt Co., in 1913; Crystal Salt Co. (sea salt), in 1915; and Gulf Salt Co. (sea salt), in 1918; while the Broken Hill Associated Smelters' sea-salt works began in 1920.

In recent years the very great advantages offered by the indented coastlines of Spencer and St. Vincent gulfs have been recognized, affording as they do cheap transport and locations for works within the area of high net evaporation and abnormal salinity of the sea-water. The Crystal Salt Co., Ltd., has established works at the head of Spencer's Gulf, near Port Augusta; the Gulf Salt Co. is completing works at Price, on the eastern shore of Yorke Peninsula for the recovery of salt from sea-water; and the Broken Hill Associated Smelters at Port Pirie is taking steps to recover salt from their cooling water, which is discharged at a height sufficient to feed the evaporating ponds.

The chief producers at present are the lakes or "playas," which fill with from a few inches to several feet of water during the period of winter rains, and which, after evaporation of the water, contain from ½ in. to 3 in. of salt, and in two cases considerably more.

The principal producing areas are: southern Yorke Peninsula, Snowtown-Port Wakefield district, Kangaroo Island, and Lake Hart. To these will probably be added a considerable production from the thick deposit of Lake Macdonnell, and it is probable that Lake Hart will contribute a greater proportion of the lake salt than it does at present.

Many other deposits of importance are known, but are likely to

[1] "Salt and Gypsum Resources of South Australia," Bull. No. 8, Geological Survey of South Australia (1921).

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remain undeveloped until changed conditions of transport bring them within the field of economic exploitation. A number of small salt-encrusted lakes occur to the southwest and south of the Gawler Ranges, but are cut off from the railway by a broad belt of sandhills.

The methods adopted in harvesting the salt depend upon the thickness of the salt and the nature of the bottom.

On Lake Bumbunga in the Snowtown-Port Wakefield district and some minor lakes, on which the salt crust is thick, the upper portion is scarified by a heavily-weighted harrow, drawn by a team of horses. On some of these lakes drays and trucks, either on a normal tram line or on a mono-rail, are used, the salt being shoveled from windrows, into which it has been gathered by horse scoops.

In one case a movable overbridge, on skids, spans the truck line, and the salt is collected by a series of two-horse scoops, which, at the center of the bridge, tip the salt through a grizzly into trucks. An output of eight tons in five minutes is reached by this method with one overbridge. At Lake Bumbunga, where these methods are in vogue, every effort is made to get the salt stacked in heaps on the bank as early as possible in the summer, to avoid the contamination by red dust from the surrounding fallowed fields. The stacked salt, from which a considerable portion of the magnesium salts has been drained, is then either bagged for sale or carted in bulk to the refinery.

On Yorke Peninsula, where the deposits are in general thinner, scarifying is only practiced where the bottom is good and the thickness of salt considerable. Hand-worked scrapers are used to loosen the upper portion of the salt, which is then scraped into piles, or windrows, and allowed to drain.

The thinner deposits, down to ½ in. and exceptionally ⅓ in., are "crusted." If the bottom is good, and the salt separates cleanly, the salt is lifted by tined forks, and thrown into windrows on an unworked strip of salt. With a muddy bottom it may be forked by workmen standing upon planks or be lifted by the men standing on the unworked salt by a tined hoe.

The salt is either bagged on the lakes and trucked on iron or wooden tramways, or taken in barrows to the bank for immediate cartage to the refinery, or is taken in bulk to stacks upon the bank to await sale or an opportunity to cart it after the harvesting is concluded. The work is done on day wages or on piecework, but many of the smaller lakes are worked by the farmers on whose land they are situated.

Piecework costs are variable, depending on the thickness of the crust, the condition of the bottom, the distance to shore, and whether the salt is bagged or stacked. Prices of from 4s. to 8s. per ton were quoted.

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Salt stacked upon the bank is little affected by rainfall, and gradually loses a considerable proportion of its magnesium salts.

All the lake salts, with one exception, suffer from the disadvantage of having to be carted by road to a railway or to a port.

One of the sea-salt companies has installed a system of belt-conveyors for the rapid harvesting of the crystallizers. The salt is stooked and allowed to drain, but in future it is probable that drains cut through the salt crust will drain the interstitial bittern sufficiently to obviate the preliminary stooking. The salt is shoveled on to a portable belt-conveyor at intervals along its length. This conveyor is readily moved as required. From this conveyor the salt passes to one at right angles, designed to serve eight ponds of an acre each, which discharges to a third at right angles to the second. This last, and the stacker belt-elevator, has a longitudinal travel on rails, so that the pile of salt can be extended longitudinally when it attains a height of 26 ft.

The salt is refined at various centers, the general outline of treatment being somewhat similar, and various grades are made to suit the requirements of the market. Salt is sold as crude, crushed crude, coarse washed, and several crushed, washed and graded sizes.

In general, the outline of the refinery work is as follows: Crushing, followed by washing in salt water, through which the salt is forced by an archimedean screw. Here dust, gypsum, mud, and organic matter are removed, as well as the more soluble magnesium salts. Losses of 18 to 30 per cent. are made at this point. Much of this is due to the removal of the magnesium salts, but a proportion of sodium chloride is lost owing to the fact that sea-water used for washing rapidly becomes salt-saturated, and finally has to be rejected owing to its increasing magnesium content.

Seven refineries are in operation in South Australia, and one, if not two, more is to be added to the number. The nominal capacity of the existing plants is over 150,000 tons of salt of all grades from "crushed crude" to table salt, so that if run to their full capacity there will be no difficulty in supplying the normal Australasian demand for some time to come.

The production of salt from sea-water is being carried on by two companies in South Australia, and though the method, unlike the lake-salt areas, requires continuous supervision and pumping charges, the total amount of labor involved in harvesting and carting is less. With the full utilization of mechanical scrapers and loaders it will be possible to eliminate the manual handling entirely. The control of the process that is possible by depositing the bulk of the gypsum in the preliminary areas, the removal of the bittern salts, and the return of wash-water to the

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brine ponds will reduce the loss of salt in refining, as there is a lesser quantity of impurity to be removed.

In many countries, while the preliminary concentration of sea-water is done by solar heat, the final stages are carried out in fuel-heated vessels of various types, adapted to the grade of the finished product it is intended to make. The position of South Australia in regard to fuel deposits makes the use of coal very costly, but the State is fortunate in that two gulfs extend far into the dry area where the net evaporation is high. Furthermore, the distribution of the annual rainfall is such that during the six months of maximum evaporation the rainfall is very low, so that no expense need be incurred for covers to the final evaporating pans as is necessary in certain more humid countries. The works, situated as they are near the heads of the gulfs, use water already concentrated in the gulfs, thus reducing pumping costs and preliminary evaporating areas.

The opportunities for solar evaporation of sea-water are not yet exhausted, suitable areas existing at intervals along the coast on the shores of St. Vincent and Spencer gulfs between Adelaide and Cowell, although it is probable that they would require a somewhat greater capital expenditure upon them to render them productive than the three existing works. They are also in general less favorably situated with regard to shipping facilities, the water being shallow along those portions of the coastline where the tidal mangrove flats occur.

The possibility of utilizing brine from beneath lake beds has also been considered.

East of Warooka a well in the Big Swamp contains a large supply of brine at 2 ft. below the surface. A sample yielded 32.29 oz. of salts to the gallon, and it is proposed to pump this on to crystallizers.

The Standard Salt Co., of Edithburgh, has sunk a well on Full Moon Lagoon into the till, and cut brine with 8 to 10 oz. of salts to the gallon at 123 ft.

Sodium Carbonate

South Africa.[1]—The management of South African Alkali, Ltd., started their plant for the production of carbonate of soda towards the end of May, at their Salt Pan property near Hamaan's Kraal.

About four years ago the trona beds were very profitably worked by the company for soda contents. These beds were the gradual accumulations resulting from the evaporation of seepages of what is now called the mother liquor, and were soon exhausted.

When the trona beds were exhausted, it was noted that the mud

[1] *So. Afr. Min. Eng. Jour.*, June 18, 1921, p. 1345.

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beds of the pan, at parts, were much impregnated with soda, and that the water in the pan, at different parts, contained varying percentages of soda and salt, and attempts were made to work, first the mud, and then the waters, economically. Then it was surmised that there might be an underground supply of better liquor, and it was decided carefully to prospect the pan by boreholes. This theory was most successfully demonstrated by a series of over twenty boreholes, which, at depths of 27 to 30 ft., proved the existence, all over the pan, below the impervious mud bottom, of apparently inexhaustible supplies of a liquid, which, on analysis, proved to be pure water with soda and salt in solution, without other impure substance at all. Each gallon of this mother liquor contains 0.9 lb. of commercial soda and 1.5 lb. of salt.

A curious fact is that the level of mother liquor, as shown by all the boreholes, is some 3 ft. higher than the level of the waters of the pan.

The problem now was how to get the soda and salt contents of the mother liquor separately and in commercial form.

The production of soda on a commercial scale, after many delays and much anxiety, is now an accomplished fact, the methods being as follows:

The mother liquor is pumped from one or other of the boreholes to the plant, and is first chilled in inverted cone-shaped vessels, of which four are at present in operation.

The liquor, when chilled, precipitates its soda contents, in the form of decahydrate of soda, to the bottom of the cone, where it is tapped off, together with a certain amount of liquor, at the rate of 750 lb. of solid decahydrate in slightly under an hour. The liquor is separated from the decahydrate by large centrifugal separators, four of which are erected. The decahydrate crystals, as separated by the centrifugal machines, have the appearance of new-fallen snow. The chemical composition of these crystals is 66 per cent. water and 34 per cent. soda, and a perplexing problem was how to get rid of the water of crystallization and secure carbonate of soda without any water.

The method adopted now is to let the decahydrate crystals dissolve, in a suitable vessel, in their own water of crystallization and then evaporate the water. This is done by feeding the melted decahydrate to a sugar-boiling vacuum pan, which has been adapted to the production of soda instead of sugar. As the liquid evaporates crystals of monohydrate of soda are precipitated and are tapped off at the rate of 1200 lb. of monohydrate of soda every half-hour. The process is continuous. It was at one time feared that the soda would scale or encrust on the steam coils and sides of the pan, but in practice it is found that there is no scaling at all.

Monohydrate of soda crystals contain 6 per cent. water of crystalliza-

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tion. The water of crystallization, together with adherent moisture, is dissipated in the Merson furnace, and commercial soda results.

A special separator for the adherent water is being installed, as well as belt-conveyors and some other improvements intended to facilitate and cheapen production.

The quality of the product is rapidly improving, and it is anticipated that the plant will yield and maintain a product of 98 per cent. soda.

It is understood than more cones or chilling vessels are being ordered. They can be made locally and cost comparatively little and are quickly made.

The refrigerator will serve ten or twelve cones as easily as the four at present in operation. The centrifugal separators can cope with the product from double the number of present cones and the vacuum pan has a capacity of nearly twice what the present cones can supply. The boiler power is also much in excess of the present machines.

The managing director estimates the running costs at about £2000 a month. The present production of soda, until the improvements above mentioned are effected, is seven tons of commercial soda daily; the local price is £26 a ton. Any surplus over local requirements will find a ready sale in Australia or Japan, though at a lower price.

The company's chemist has produced salt 99 per cent. pure in his laboratory. The plant required to produce salt commercially on a large scale is the addition of another evaporating pan only.

With the proposed additions it is estimated that there will be a production of 25 tons of soda and 35 tons of salt daily.

Sodium Sulphate

United States.[1]—The Western Chemical Co. has given publicity to plans for the erection at San Pedro, near Los Angeles, of a factory to cost $150,000, to be the first unit of what is to be a great plant to handle the threnardite secured from a lease of 600 acres of Arizona state lands in the neighborhood of Camp Verde, Ariz. The material is to be purified into commercial sodium sulphate for paper and glass manufactures; sodium sulphide, used in the tanning and dye industries; Glauber's salt, and hyposulphites. An active market for the sulphate already has been developed in Sweden, Norway and Denmark, where the paper mills have offered to take the new mill's entire output of 200 tons a day.

In view of the unsettled trade conditions, the proffered contracts have not been closed, the same disposition having been made of pending South American contracts. The new plant will be on the west basin of

[1] *Eng. Min. Jour.*, **112**, 385 (Sept. 3, 1921).

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Los Angeles Harbor, where the raw material will be received from railroad cars and the product transferred by gravity into deep-sea vessels. The company already has a $200,000 plant 30 miles west of Tonopah, Nev., turning out 20 tons a day each of potash-alum and flowers of sulphur.

Canada.[1]—Only one firm in Saskatchewan produced sodium sulphate during the year, the total quantity mined being less than 300 tons. Two firms, however, made shipments amounting to approximately 600 tons during the period. The value of the shipments was in the neighborhood of $9500, an average of $16.28 per ton.

[1] Prelim. Rept. Min. Prod. of Canada, 1921, Dominion Bur. of Statistics.

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SULPHUR, PYRITE AND SULPHURIC ACID

By Arthur E. Wells

Sulphur

At the present time the world's sulphur market is dominated by the American production. Compared with other commodities, sulphur is today cheaper than ever before in its history, and the market bears promise of remaining stable. This fact is due to the immense reserves in the American deposits, and the fact that they are mined by well-financed competing companies who keep large stocks on hand above ground. The consumer can rest assured that sulphur will be readily available at a reasonable price for many years to come.

About ninety-nine per cent. of all the sulphur produced in the United States comes from the Gulf Coast deposits. During 1921 practically all the sulphur production came from two properties, that of the Texas Gulf Sulphur Co. at Big Hill, Matagorda County, Texas, and that of the Union Sulphur Co. at Sulphur, Calcasieu Parish, Louisiana.

The property of the Freeport Sulphur Co., at Bryan Mound, in Brazoria County, Texas, was closed down early in 1921.

The Texas Co. has a lease on sulphur property at Hoskins Mound, in Brazoria County, Texas, and has entered into contract with the Freeport Sulphur Co. for the operation of the property, and the construction of a complete plant at Hoskins Mound is now under way.

The deposits of the Gulf Coastal Plain occur in the so-called "saline domes." These domes are practically all under ground, the tops scarcely rising above the surrounding surface. The visible elevation is generally from 10 to 15 ft., although the maximum goes as high as 80 ft.

More than twenty of these "saline domes" have been located along the Coastal Plain, scattered over an area about 200 miles in length, extending through western Louisiana and eastern Texas, and generally within 50 miles of the Gulf of Mexico.

It is quite possible that the level plain conceals deposits of great value, but their discovery will necessarily be more or less accidental.

The upper strata of the dome are made up of unconsolidated sediments. Beneath these lies the salt dome proper. Its upper portion consists of layers of limestone and gypsum, while beneath, a great salt bed extends downward to unknown depths.

The sulphur is found in the limestone zone, at a depth of 300 to 1200 ft. This zone is the seat of the petroleum sometimes found in immense quantities.

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The existence of these sulphur deposits was discovered about forty years before they began to be successfully exploited. In the meantime, many attempts were made to mine them by shaft methods, but all failed completely and caused considerable loss of life. The main difficulties encountered were due to the unconsolidated nature of some of the layers above the deposits (quicksands), the great water pressure, and the poisonous gases emitted.

About the time that it seemed impossible to mine the sulphur from these rich deposits, Herman Frasch conceived the idea of melting the sulphur in place by means of superheated water, and obtained his first patent in 1891.

The Frasch patents were acquired by the Union Sulphur Co., which developed the deposits in Calcasieu County, Louisiana. Until this last year, the Union Sulphur Co. was the largest producer of sulphur in the district. The production of the Union Sulphur Co. since 1902 is shown in the following table:

	Tons.		Tons.
1903	23,715	1911	204,220
1904	79,187	1912	786,605
1905	218,950	1913	478,565
1906	287,590	1914	804,470
1907	185,882	1915	379,885
1908	367,896	1916	383,465
1909	270,725	1917	575,130
1910	246,510	1918	978,700

In 1908 the Frasch patents expired, and the practical monopoly of the sulphur business in this country enjoyed by the Union Sulphur Co. legally expired with them.

In 1912 the Freeport Sulphur Co. started operations, but no substantial amounts of sulphur were extracted until 1916. In 1917 this company extracted its maximum production, more than 500,000 tons.

One of the largest, perhaps the largest, centralized deposit of sulphur in the world is that in the "Matagorda dome" in Texas. In 1918 the almost insatiable demand of the Federal Government for sulphuric acid and the belief that the sulphur industry is a basic and permanent one led to the formation of the Texas Gulf Sulphur Co., which undertook to open up this deposit, using the superheated-water method of mining. In spite of the exceptional difficulties attending any construction work at that time the plant was completed within nine months. Mining operations began on Mar. 9, 1919, and have been continuous ever since. The plant was designed to have a capacity of at least 1000 tons a day, but the output can be forced to three or four times that amount, using the present equipment.

The suit of the Union Sulphur Co. vs. Texas Gulf Sulphur Co., in which the plaintiff asked $6,768.000 damages for sulphur removed from

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its land by the defendant, has been settled out of court and has been dismissed by the Federal Court at Houston.

SULPHUR PRODUCED AND SHIPPED IN THE UNITED STATES (a)

Year.	Mined.	Shipped.		Year.	Mined.	Shipped.	
	Quantity, Long Tons.	Quantity, Long Tons.	Approximate Value.		Quantity, Long Tons.	Quantity, Long Tons.	Approximate Value.
1909	273,983	258,283	$4,783,000	1917	1,134,412	1,120,378	$23,987,000
1910	247,060	250,919	4,522,000	1918	1,353,525	1,266,709	27,868,000
1911	205,066	253,795	4,573,000	1919	1,190,575	678,257	10,252,000
1912	787,735	305,390	5,289,000	1920	1,255,249	1,517,625	30,000,000
1913	491,080	319,333	5,614,000	1921	1,879,150	954,434	18,000,000
1914	417,690	341,985	6,214,000				
1915	520,582	293,803	3,955,000				
1916	649,683	766,835	12,247,000				

(a) U. S. Geol. Surv.

Exports in 1916 exceeded imports by 107,000 tons, and were valued at over $2,500,000. They showed increased valuation for each year thereafter. The annual growth in the export trade and the corresponding decline in imports during the past eleven years is shown in the following table, compiled from statistics from the Bureau of Foreign and Domestic Commerce:

EXPORTS AND IMPORTS OF CRUDE SULPHUR

	Exports.		Imports.	
	Long Tons.	Value.	Long Tons.	Value.
1910	30,742	$552,941	28,647	$495,988
1911	28,103	545,420	24,250	436,725
1912	57,736	1,076,414	26,885	494,778
1913	89,221	1,599,761	14,636	278,056
1914	98,163	1,807,324	22,810	409,537
1915	37,271	724,679	24,647	405,990
1916	128,755	2,505,857	21,510	364,787
1917	152,736	3,500,819	973	20,176
1918	131,092	3,626,638	55	1,692
1919	224,712	6,325,552	77	1,997
1920	477,450	8,994,350	44	1,722
1921	285,762	4,524,788	4	226

Sulphur mined by the Frasch process has an extraordinary degree of purity. As pumped out of the ground it is 98 per cent. pure, and occasionally, excluding moisture, runs 99.9 per cent. pure.

The sulphur of all three American companies contains minute traces of oil and its presence occasionally leads the consumer to believe that the sulphur is fairly impure.

A very slight oil content, 0.1 per cent., shows itself by the color, the odor, and the peculiar burning properties of the sulphur. To illustrate: If two small samples of sulphur, one chemically pure, the other with 0.2 per cent. petroleum oil, are ignited, the former burns until entirely consumed. As the latter burns, a film gradually grows over the surface, extinguishing the flame as it spreads, until it has put it out entirely, leaving most of the sulphur unconsumed.

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However, if the sulphur is burned in a rotary or cascade-type burner in which the surface of the sulphur is agitated, no trouble is experienced even when the oil content of the sulphur runs as high as 0.2 per cent., which happens only exceptionally.

Now that the deposits have been opened up for some time, trouble from the oil content of the sulphur is no longer anticipated.

All the large deposits are near oil fields and it is assumed that when the hot water is first sent down into a deposit it carries the oil encountered in sand pockets to the sulphur beneath. As operations continue the enormous amount of water used washes the oil pretty well out, so that the sulphur pumped to the surface has an increasingly smaller oil content. The sulphur as it naturally exists contains no oil, as examination of the various drill cores reveals.

Sulphur in Foreign Countries

Argentina.[1]—Industries that utilize sulphur as a raw material, such as sulphuric acid and carbon bisulphide, have been established in Argentina for some time past, but the sulphur required has always been imported, as the deposits which were known to exist in the country were not worked owing to lack of transport and other difficulties. The war, however, necessitated the development of home resources, and in investigations showed the existence of sufficient sulphur not only for local requirements, but for exportation on a large scale. Although most of the deposits are too poor to exploit, others contain extremely good sulphur.

Deposits occur in the Province of Mendoza, at Overo and Petarva, both extinct volcanoes, and in San Juan, where it is associated with gypsum. The richest and most promising deposits, however, occur in the Andes, but only partly on Argentine soil. The deposit at the Tucley volcano, which was the first to be exploited, is inexhaustible, but exploitation is rendered difficult by lack of water and coal and the necessity of working at an altitude of 13,000 ft. The cost of production at present is about 6 pesos (1 peso = 96.5 cts.) per ton of rock, containing about 33 per cent. sulphur, but owing to heavy freight charges the price in Buenos Aires is 150 pesos. Should, however, the projected Transandean railway be constructed, it will become possible to open up the Tucley deposit, and to produce sulphur that can compete with the imported product.

France.—Following are the sulphur exports and imports of France for 6 years, in metric tons:

[1] *Am. Fert.*, Nov. 5, 1921.

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Year.	Exports.	Imports.
1915	11,608	99,395
1916	17,301	128,095
1917	5,532	76,866
1918	8,652	71,886
1919	4,051	139,958
1920	30,460	237,912

Germany.[1]—Germany is making great efforts to become independent of foreign resources. Before the outbreak of the war, considerable quantities of sulphur were produced within the country. In 1912 no fewer than 109 factories were engaged in the manufacture of sulphuric acid, with a combined production of 1,650,000 tons per year. During the same year 2,017,000 tons of sulphur-bearing minerals were worked up, of which, however, only 999,000 tons was mined in the country. On account of war, conditions underwent radical changes, as Germany was cut off from any importations of sulphur as well as raw materials. For this reason the exploitation of the domestic pyrite deposits assumed large proportions, and alone in the district of Meggen, in Westphalia, the production of cupriferous gravel, sulphuret of zinc and lead, and other sulphur-bearing minerals, rose from 200,885 tons in 1914 to 766,371 tons in 1920.

A new process by which sulphur is gained from gypsum and sulphate of magnesium is being improved at present. Germany requires 140,000 tons of sulphur (as sulphur or pyrite) per month. In 1917 the monthly production of sulphur from domestic raw materials amounted to 64,000 tons, and it has largely increased during the last four years.

Italy, Including Sicily.—The gradual decline of the Sicilian sulphur industry in recent years is clearly shown by the following statistics in metric tons:[2]

Years.	Production.	Stocks on hand.	Exports.	Years.	Production.	Stocks on hand.	Exports.
	Metric Tons.	*Metric Tons.*	*Metric Tons.*		*Metric Tons.*	*Metric Tons.*	*Metric Tons.*
1904	499,322	370,606	490,090	1913	345,548	376,365	414,716
1905	538,534	462,865	469,730	1914	334,974	369,001	338,308
1906	475,553	537,588	399,100	1915	319,260	323,860	359,806
1907	403,538	598,709	343,950	1916	233,835	155,372	396,035
1908	404,297	616,419	377,610	1917	177,453	156,800	162,971
1909	402,353	647,880	364,953	1918	194,585	112,050	230,769
1910	397,808	641,249	395,944	1919	181,744	136,991	147,286
1911	376,161	551,422	456,227	1920	224,247	147,886	189,878
1912	356,555	450,917	447,590	1921	240,089	273,579	105,063

The total Italian production of the past few years is as follows:

	Metric Tons.
1913	386,310
1914	377,843
1915	358,107
1916	269,347
1917	211,847
1918	234,206
1919	226,126
1920	258,000
1921	313,400

[1] *Eng. Min. Jour.*, Aug. 13, 1921.
[2] *Comm. Rept.*

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TOTAL EXPORTS OF SULPHUR FROM SICILY
(In metric tons)

Country.	1914.(d)	1915.(d)	1916.(a)	1917.(a)	1918.(a)	1919.(d)	1920.(d)	1921.(d)
Austria	25,306	70	.....	.....	.....	137	736	1,317
Belgium	5,975	.....	.....	.....	.....	2,152	3,711	122
France	60,773	96,156	107,311	68,565	90,376	69,072	37,163	4,822
Germany	18,826	391	.....	.....	.....	590	4,784	4,658
Greece and Turkey	20,746	19,857	15,384	3,893	7,590	18,826	10,895	17,130
Holland	8,080	1,163	524	.....	.....	1,119	1,207	1,388
Italy	97,170	116,601	76,502	53,748	43,631	32,015	55,035	44,058
Portugal	17,604	21,004	13,994	5,749	12,480	7,876	32,017	8,425
Spain			8,127	2,017				
Scandinavia (c)	25,294	24,832	26,450	2,500	1,769	1,701	6,412	2,027
Russia	21,290	2,791	19,947	6,578	.....	306	1,433	153
United Kingdom	12,991	36,156	68,349	20,114	62,595	3,689	11,698	4,118
United States	1,406	2,054	612	.....	.....	.....	165	.....
Other countries(b)	22,883	38,731	62,440	4,213	12,263	9,803	24,624	16,845
Totals	338,344	359,806	396,035	168,487	230,769	147,286	189,878	105,063
Stock in Sicily, Dec. 31	369,001	274,069	155,376	158,812	111,914	136,991	147,886	273,579

(a) Statistics of the International Institute of Agriculture, Rome. (b) Mainly South Africa, Northern Africa, Asia, Australia, and the East Indies. (c) Including Norway, Sweden and Denmark. (d) Reported by Parsons & Petit, New York.

During the existence of the Anglo-Sicilian Sulphur Co., Ltd., from 1896 to 1906, and later under the compulsory consortium or syndicate prompted by the Italian Government, there was an agreement with the large sulphur producers in the United States as to the division of foreign fields for the marketing of sulphur. However, this agreement in the last ten years has not been in force, and American sulphur has entered the European market.

Rotterdam, Hamburg and Antwerp have become centers of distribution for the American product in northern Europe and Marseille in the Mediterranean. In the latter place a large plant was established for the preparation of refined, ground, and other varieties to compete with similar Sicilian products.

During the war sulphur, which was required for the production of ammunition, was in great demand, but, owing to the lack of tonnage, the shipment of American sulphur to Europe was interrupted. The Italian Government commandeered the sulphur trade, authorizing exportation only with special permits. Now that freights are again normal, American sulphur exporters are everywhere underbidding the Sicilian product. The Sicilian product has been completely displaced in the important Scandinavian markets, and is facing keen competition in Belgium, England, the Netherlands, France, Germany and Africa.

The sulphur deposits on the Island of Sicily are still being exploited in the most primitive manner. The cost of production during the war and the following years was fivefold as high as in pre-war times. The high cost of living was, to a large extent, responsible for this increase.

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In 1914 the cost of production was 80 to 85 lire per ton; in 1920, however, 420 to 430 lire. The selling price at Sicilian ports rose from 110 to 115 lire in 1914 to 650 lire in 1920. Great efforts are now being made further to increase production. Thousands of children are still employed in the Sicilian sulphur mines.

The crisis in the Italian sulphur industry became acute during 1921, culminating in the strike of some of the miners, who refused to accept a decrease in wages in view of the fact that the price of food had increased considerably.

An important meeting was held in Rome to discuss means of assisting the sulphur industry. Representatives of the mine owners, mine operators, laborers, and refiners were in conference with representatives of the Italian Government.

The object of the meeting was to arrive at a method of reducing the cost of production. The following subjects were taken up and thoroughly discussed: Reduction of war taxes, reduction of railway freights, reduction of the royalty, reduction of salaries, refining, and extension of the consortium to apply to all Italy. The meeting adjourned without having attained any results.

In September, 1921, it was reported in the *Mining Journal* that no improvement existed in the position of the Sicilian sulphur industry, the depression being so serious that, if the Government had not prohibited the importation of foreign sulphur, the native product would probably have been driven out of the market, even in Sicily itself. The Italian Parliament is said to be considering the advisability of dropping the import prohibition in favor of the imposition of a heavy import duty.

It is said that American sulphur is superior to the Sicilian for the chemical industries. However, the latter is preferred locally for the vineyards, where it is used to protect the foliage against parasites, because it is said that the flour-milled product from the United States does not adhere to the leaf to the same extent as does the Sicilian. Partly for this reason and partly because of their geographic location France, Spain, Portugal, Algeria, and Greece still look to Sicily for sulphur to be used in their vineyards.

New Hebrides.[1]—The mountain of Vanua Lava, in the Banks Group of the New Hebrides, is reported to contain a vast deposit of sulphur.

Vanua Lava, as part of the Banks group, is included in the administration of the Condominium Government of the New Hebrides. The Banks group lies between the fifteenth and the twentieth degrees of south latitude and is about 900 miles from the Queensland coast.

Twenty-five years ago a French company began operations on the

[1] *Comm. Rept.*, Dec. 19, 1921.

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mountain, employing competent engineers. The company built a long, substantial, coral-concrete wharf and a storehouse in a small bay at the foot of the mountain and constructed an aerial railway up the mountain-side for nearly 900 ft. Hundreds of natives were employed in digging out the sulphur and hundreds more in carrying 50-lb. bags of sulphur to the railway terminus, whence carriers were sent rapidly to the store-house on the bay. The first shipment of sulphur sent to France paid handsomely, but the company suddenly left the field, giving as a reason that malarial fever of a malignant type made it impossible for white men to live on the mountain island.

It was eventually stated, however, that the company had learned that the administration of the New Hebrides was not in a position to guarantee the company a monopoly, a prior right from an Australian engineer, the original discoverer of the commercial possibilities of the island, being in existence. Today this claim holds good, but Condominium law prevents any prompt commercial activities on the island. A British-Australian company is now endeavoring to begin operations, and has opened up negotiations with the Condominium Government.

Norway.—The following table shows the imports and exports of sulphur by Norway from 1912 to 1921, inclusive, in metric tons:

Years.	Imports.	Exports.	Years.	Imports.	Exports.
1912	13,911	1,003	1917	4,071	.....
1913	15,411	117	1918	3,036	.....
1914	10,347	334	1919	650	.....
1915	6,804	41	1920	10,346	50
1916	7,262	.....	1921	4,869	.....

WORLD'S PRODUCTION OF SULPHUR (*a*)
(In metric tons)

Year.	Austria. (*b*) (*e*)	Chile.	France. (*b*)	Germany.	Greece.	Italy. (*b*)	Japan.	Spain.	United States. (*g*)	Total.
1905	8,542	3,470	4,637	178	1,126	568,927	24,652	610	218,440	830,609
1906	15,258	4,598	2,713	176	(*d*)1,000	499,814	27,589	700	298,704	845,956
1907	24,199	2,905	2,000	811	(*d*)1,000	426,972	33,329	3,612	312,731	807,559
1908	17,429	2,705	2,189	1,185	(*d*)1,000	445,312	33,419	13,872	312,700	829,437
1909	12,856	4,508	2,900		(*d*)1,000	435,060	36,317	21,750	303,000	817,608
1910	15,976	3,823	2,641	1,272	.....	430,360	43,848	30,113	259,699	787,732
1911	15,856	4,451	1,200	1,251	174	414,671	52,064	40,662	246,300	776,629
1912	14,979	4,431	1,000	(*c*)	2,016	357,547	55,005	42,344	308,530	785,852
1913	10,561	6,647	659	.....	*Nil.*	386,310	59,481	62,653	316,783	806,386
1914	20,314	10,008	.....	.....	*Nil.*	377,843	75,308	47,180	347,491	(*f*)877,000
1915	3,180	9,767	388	.....	*Nil.*	358,107	73,369	28,937	299,133	(*f*)860,000
1916	.....	14,876	700	.....	*Nil.*	269,374	108,100	46,923	779,181	1,219,104
1917	.....	18,938	704	.....	*Nil.*	211,847	117,990	84,979	1,138,416	1,572,874
1918	.....	19,553	4,200	.....	.....	234,296	64,696	72,360	1,287,103	1,682,208
1919	.....	.....	.....	.....	.....	226,126	67,382	89,586	680,800	.....
1920	.....	.....	.....	.....	.....	263,603	21,147	.....	1,542,059	.....
1921	.....	.....	.....	.....	.....	284,600	25,000	.....	969,800	.....

(*a*) From the official reports of the respective governments. The sulphur recovered as a by-product by the Chance-Claus process in the United Kingdom, amounting to between 20,000 and 30,000 long tons annually, is not included. (*b*) Crude mineral; limestone impregnated with sulphur. (*c*) Not yet reported. (*d*) Estimated. (*e*) Includes such production from Hungary. (*f*) Totals estimated by the International Institute of Agriculture, Rome. (*g*) Shipped from mines.

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Uses of Sulphur

The uses of sulphur are so varied that a complete description cannot be given herewith. The following table, prepared from data by Raymond F. Bacon and Harold S. Davis,[1] serves to point out the important part sulphur plays in the basic industries.

CHIEF USES OF SULPHUR
(In per cent. of total)

Agriculture	8.8	Elastic	
Fertilizers		Sheet rubber	
Fungicides		Miscellaneous rubber goods	
Insecticides		Sulphur Dioxide	25
Carbon Disulphide	3.1	Bleaching	
Fire extinguishers		Explosives	
Insecticide		Fumigants	
Poison (for pests)		Paper manufacturing	
Solvents		Photography	
Direct Use	2.8	Sulphuric Acid	52
Cements		Chemicals	
Fumigating		Explosives	
Medicine		Fertilizers	
Sulphuring		Galvanising	
Rubber Industry	8.3	Petroleum industry	
Belting		Steel industry (pickling)	
Ebonite		Sugar industry	

Unquestionably the use of sulphur for purposes old and new will steadily increase. Realizing this, the Texas Gulf Sulphur Co., coincident with the beginning of its operations, inaugurated a systematic scientific research on sulphur. Broadly speaking, the work has meant a careful study of the substance itself, with the object of obtaining light on methods of mining, on the difficulties met by the consumer in handling sulphur, and on possible new uses.

Those properties which suggest certain possible tonnage uses for sulphur are its exceptional insulating qualities, its resistance to being wetted by water, and its inertness towards most acids,—all these combined with a fair degree of physical strength.

As a cement, either alone or combined with sand, sulphur has been successfully used for many purposes. For example, sulphur is now being used to set bricks in certain acid towers; paving bricks have been laid with sulphur with entire satisfaction.

Perhaps the chief obstacle which has prevented a steady increase in the use of sulphur for such purposes has been the novelty of the art of melting sulphur. Melting in a large open dish is extremely unsatisfactory. Unless the mass is well stirred its temperature goes up and the sulphur becomes viscous and may even take fire. To obviate these difficulties a new type of melter has been developed at the Mellon Institute. The design is simple and has proved very efficient. A complete description will be published at an early date.[2]

[1] *Trans. Am. Inst. Chem. Eng.*, December, 1920.
[2] Harold S. Davis, *Can. Chem & Met.*, October, 1921, p. 295.

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Once melted, the sulphur is easily kept so by steam-jacketed kettles under a pressure of about 30 lb., and can be transported long distances through pipes with a steam-line in the center.

Engineers are naturally and properly conservative about the introduction of new materials into construction work. Still, sulphur is about as easily handled as asphalt, so that when concrete and other familiar materials fail, they will do well to keep in mind this old familiar substance which is now so readily available.

Sulphur as a Fertilizer.—Considerable interest has been manifested in the use of sulphur as a fertilizer. Results at the Oregon Agricultural Experiment Station have shown that sulphur gives good results upon alfalfa in certain soils. Experiments at various other stations have also indicated a use for sulphur for certain soils, but there have been no developments which would indicate any large use for this purpose, at least for many years to come. Practically all soils need phosphoric acid and nitrogen more than they need sulphur.

Sulphur from Blast-furnace Slag[1]

In the investigation of every available source of sulphur, Prof. L. H. Diehl, of Oberhausen, Germany, started to produce sulphur from slag.

The slag production in Germany before the war was approximately 20,000,000 tons, with sulphur running from 1 to 2.25 per cent. and averaging 1.50 per cent. This represents at least 300,000 tons of sulphur thrown away each year. Because of this large available supply, efforts were made to develop it and the method worked out was protected by a war patent.

The Diehl process consists in obtaining sulphuric acid by oxidation of the calcium sulphide in blast-furnace slag by means of air or by sulphates such as gypsum or anhydrite, with the help of air. The chemical reactions are very simple. The calcium sulphide unites with oxygen and gives lime which changes to orthosilicate, and at the same time free sulphur is liberated. With sufficient excess of air this is burned, but if not burned it passes off as elemental sulphur with the gases.

$$CaS + O + CaSiO_3 = Ca_2SiO_4 + S$$
$$S + O_2 = SO_2$$

The reaction when calcium sulphate is present is as follows:

$$CaS + 3CaSO_4 + 4CaSiO_3 = 4Ca_2SiO_4 + 4SO_2$$

It should be mentioned that calcium sulphide and sulphate cannot exist together in a molten silicate slag, as is the case in the solid condition.

[1] *Iron Age*, Feb. 2, 1922.

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Because of the low sulphur content of blast-furnace slag, which precludes remelting or subsequent treatment, all the work was done on the molten slag as it came from the furnace by blowing air through it. Preliminary tests carried out with molten slag and oxygen gave a gas containing 23.1 per cent. SO_2 by volume. Further experiments showed that a shot-shaped tuyere gave a richer gas than a round one. Following these tests an apparatus was designed that has been used successfully for several months at Gutehoffnungshutte.

A very rich gas can be obtained if a sulphate such as calcium sulphate is added to the slag while air is blown in. In this way the heat of the slag is used for decomposition. After treatment the slag can be used exactly as before, and for granulating, slagwool, building purposes, etc., it is better because of the lower sulphur content.

Pyrite

Very little domestic pyrite was sold in the United States during 1921, except in California. California produced and consumed 98,252 long tons out of a total of 157,118 tons.

The domestic pyrite producer in the East and South cannot compete with brimstone or the Spanish pyrite. The cost of production at the pyrite mine in the East is at least 12 cts. per unit of sulphur contained, which cost, with the freight charges, prevents any marketing of the ore, except possibly to acid plants distant from the Atlantic seaboard and immediately adjacent to the mines. There is no prospect for more favorable market conditions for domestic pyrite than in 1920 and 1921.

During the World War it became necessary to examine and estimate our domestic ore reserves with a view of supplying the increased demand for certain mineral products, among them sulphuric acid, which is made largely from pyrite. One of the most promising developments in this connection is the conversion of the well-known Haile gold mine near Kershaw, S. C., into a pyrite mine.[1] This mine has been the largest single producer of gold in the Appalachian region. It was successfully worked for gold from 1830 to 1908 and produced during that period $3,500,000 in gold. Much of the gold was mined from huge open pits 200 ft. in depth.

The pyrite ore in sight at this mine amounted to about 100,000 tons, and the mine was estimated to contain 600,000 tons, which is about half the quantity annually used by the United States and more than the annual domestic production.

The ore now mined consists of pyrite abundantly diffused through a gangue of sericite and quartz. The pyrite is very fine grained and

[1] *Press Bull.* 12,264, U. S. Geol. Surv., 1921.

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relatively pure. It increases in amount with depth and extends below the deepest workings, whose depth is 350 ft. In exploiting it test drill-holes are sunk nearly to that depth. A large part of the deposits can be most advantageously worked in open pits with a steam-shovel. In concentrating the ore jigs, settling tanks, and Wilfley tables are used.

PRODUCTION, IMPORTS AND CONSUMPTION OF PYRITE IN THE UNITED STATES (a)
(In tons of 2240 lb.)

Year.	Production.		Imports. (b)		Consumption.	
1907	261,871	$851,346	656,477	$2,637,485	918,348	$3,488,831
1908	206,471	744,463	668,115	2,624,339	874,586	3,368,802
1909	210,000	756,814	692,385	2,428,638	902,385	3,185,452
1910	223,700	830,150	806,590	2,773,627	1,303,402	3,603,777
1911	301,458	1,164,871	1,001,944	3,788,682	1,301,848	4,953,503
1912	350,928	1,334,259	964,478	3,860,738	1,315,406	5,194,997
1913	341,338	1,286,284	850,592	3,611,186	1,192,930	4,897,421
1914	336,662	1,283,346	1,026,617	4,797,326	1,363,279	6,080,672
1915	394,124	1,374,933	964,634	4,817,977	1,358,758	6,492,910
1916	439,132	2,038,002	1,244,519	6,728,318	1,683,651	8,766,320
1917	482,662	2,593,035	967,340	5,980,457	1,450,002	8,573,492
1918	464,494	2,644,515	498,786	2,767,448	963,280	5,411,963
1919	420,647	2,558,172	388,973	2,176,565	809,620	4,734,737
1920	310,777	1,597,000	332,606	1,660,832	643,383	3,257,832
1921	157,118	700,000	216,229	818,852	373,347	1,518,852

(a) U. S. Geological Survey. (b) Net imports, less re-exports.

The controlling elements in the pyrite situation are the price of domestic sulphur, Rio Tinto, and ocean freight-rates. The trend of foreign imports is shown in the following table:

IMPORTS OF PYRITE (a)
(In tons of 2240 lb.)

	From Spain.	From Canada.	Total. (b)
1916	1,095,980	148,682	1,244,519
1917	747,830	210,615	967,340
1918	270,649	221,442	498,786
1919	280,725	84,761	388,973
1920	200,706	100,672	332,606
1921	191,515	7,000	216,229

(a) Bureau of Foreign and Domestic Commerce.
(b) Includes importation from other countries also.

The low price of sulphur following the war and the fact that many acid-manufacturing companies had installed sulphur burners and found it inexpedient to return to imported pyrites resulted in the curtailment of market indicated in the figures given. Low-grade pyrites has almost disappeared, and only the high-grade Rio Tinto product holds a place in the markets.

At present the pyrites business is on a hand-to-mouth basis, and there are no stocks. On the other hand, the sulphur stocks are large and can be shipped by carload or cargo. With a decrease in ocean freight-rates the competition between foreign pyrites and domestic sulphur has become keener. The importers of pyrites look hopefully for better business in 1922.

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The industrial depression has also played an important part in restricting the market. The great majority of acid manufacturers have not dismantled their pyrites burners, and this has had its influence upon sulphur prices. If Rio Tinto decides to fight for its United States market, it will be at its own and the domestic sulphur producers' cost.

Two kinds of pyrite are recognized upon the market, "furnace ore," or lump, and fines. Lump ore ranges in size from 2 to 10 in., and the proportion of fines must not exceed 10 per cent. past a ½- or ⅜-in. screen. All material past a ½- or ⅜-in. screen is sold as "fines," the price differential being usually 2 cts. per sulphur unit less than for lump ore. Sometimes the "ore" is sold as run-of-mine, but this kind is objectionable, as it usually carries a large proportion of fines. Should the furnace or lump ore contain a greater percentage of fines than the 10-per cent. maximum, the allowances to be made would be subject to negotiation. The same would apply to the fines if there were any pieces that failed to pass the limit screen size.

Pyrite is always shipped in bulk and frequently foreign pyrite is shipped as ballast. Shipments are usually c.i.f. (cost, insurance, and freight) and delivery is made from the "ship's tackle." Occasionally, contracts are made on an f.a.s. (free alongside ship) basis, and under this designation the consignee takes the ore out of the steamer after the ship has been placed alongside the pier. Cargoes are often distributed among several different consumers, each taking from 500 to 1000 tons. This makes it easier for the seller to finance the sale and avoids a loss due to the interest on his purchase. Although buyers do not especially care to take large quantities of pyrite during the early spring or fall, no cut in price on deliveries is made at these times.

An important feature in the pyrite situation is the disposal of the cinder. About 70 tons of cinder containing from 2 to 3 per cent. sulphur result from the burning of 100 tons of pyrite. By nodulizing or sintering, the sulphur content can be reduced and the product equals a Bessemer iron ore, the phosphorus content being very low.

Tariff.—During the year an attempt was made to place a duty on pyrite. It was concluded by the U. S. Tariff Commission for the Committee on Ways and Means, however, that ". . . American sulphur producers, regardless of any tariff duties, enjoy comparative advantages making them independent of foreign competition . . . American pyrite producers can expect little, if any, benefit either from a duty on sulphur or one on pyrites. The serious competition which domestic pyrites producers face comes from American sulphur, not from imported pyrites."

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WORLD'S PRODUCTION OF PYRITE
(In metric tons)

Year.	Belgium.	Bosnia.	Canada.	England.	France.	Germany.	Greece.	Hungary.	Italy. (a)
1907..	397	3,671	35,494	10,357	283,000	196,320	*Nil.*	99,503	126,925
1908..	357	10,403	42,934	9,599	284,717	219,455	6,868	95,824	131,721
1909..	214	7,266	58,645	8,564	273,221	198,688	14,740	98,971	149,084
1910..	213	571	48,871	10,393	250,432	215,708	33,294	92,464	165,688
1911..	122	3,118	74,978	10,276	277,900	217,459	35,960	96,754	165,273
1912..	148	6,216	73,944	10,691	282,202	242,121	29,766	103,809	277,585
1913..	268	3,242	143,882	11,611	311,187	268,600	128,880	106,629	317,334
1914..	109	4,459	204,125	11,848	199,326	232,300	129,150	102,370	335,531
1915..	129	(b)	259,494	10,711	196,606	641,600	12,113	(b)	369,320
1916..	212	9,255	280,552	10,656	219,371	635,700	19,938	(b)	410,290
1917..	81	2,803	377,984	8,652	280,797	803,700	9,535	(b)	500,782
1918..	6	(b)	373,418	22,552	260,310	(g)817,883	12,433	(b)	482,060
1919..	60	(b)	161,016	7,455	118,703	359,203	2,354	(b)	372,574
1920..	*Nil.*	(b)	158,528	6,796	131,412	(b)	2,599	(b)	321,589
1921..	(b)	(b)	22,170	(b)	172,370	(b)	(b)	(b)	448,600

Year.	Japan.	Newfound-land.	Norway. (c)	Portugal. (c)	Russia.	Spain.	Sweden.	United States.	Total.
1907 ..	56,166	28,000	236,038	241,771	18,316	225,830	27,000	266,061	1,854,849
1908 ..	33,867	(e)35,000	269,129	81,417	56,345	263,457	29,569	209,774	1,780,436
1909 ..	27,066	*Nil.*	282,606	284,735	46,078	236,000	16,104	213,371	1,915,353
1910 ..	78,418	*Nil.*	322,000	312,906	55,980	294,184	25,445	227,280	1,860,148
1911 ..	73,879	2,500	350,000	282,773	113,054	344,879	30,096	304,974	2,383,995
1912 ..	74,929	*Nil.*	469,326	(f)601,443	123,990	421,070	31,835	356,707	3,105,782
1913 ..	114,589	.....	441,219	(f)391,083	e)130,000	926,913	34,319	347,027	3,636,478
1914 ..	115,842	.....	414,886	(a) 73,404	(b)	984,885	33,313	342,082	3,145,000
1915 ..	67,536	.....	513,335	(b)	(b)	802,383	76,324	399,469	.....
1916 ..	91,102	.....	295,354	(b)	(b)	953,679	97,848	446,202	.....
1917 ..	121,349	.....	328,694	(b)	(b)	976,918	142,660	490,433	.....
1918 ..	105,796	.....	338,849	(b)	(b)	590,008	141,181	471,972	.....
1919 ..	(b)	.....	309,011	52,404	(b)	431,189	108,770	427,419	.....
1920 ..	(b)	.....	333,011	245,811	(b)	(b)	107,326	279,427	.....
1921 ..	(b)	.....	(b)	(b)	(b)	(b)	(b)	159,648	.....

(a) Cupriferous in part. (b) Reports not yet available. (c) Both iron and copper pyrites. (e) Estimated. (f) Includes 120,148 tons copper iron pyrite in 1912 and 13,550 tons in 1913. (g) Prussia alone.

Foreign Countries

Canada.[1]—The shipments of pyrite (both iron and copper) as sulphur ores have decreased very considerably since 1918. The total shipments during 1921 amounted to 28,001 short tons valued at $124,116, and included 21,004 tons from Ontario, 80 tons from Quebec and 4607 tons from British Columbia. From reports at hand the 1921 production was less than 20 per cent. of the production for the preceding years.

The percentage of sulphur in the ore varied from 33.6 to 42 per cent. At the average of 34.7 per cent. the sulphur content amounted to 3531 tons.

A shipment of 516 tons of copper ore was exported from Quebec to United States smelters, which contained about 400,000 lb. of sulphur. During 1920 the customs records showed exports of pyrites as 119,136 tons valued at $458,403.

[1] Prelim. Rept. Min. Prod. of Canada, 1921, Dominion Bur. of Statistics.

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Spain and Portugal.—During 1921 Spanish mine operators were much disturbed by a proposed export duty on pyrite. This was stated to be as much as 8 pesetas per ton of ore containing up to 2½ per cent. of copper, and more for higher grade. In defence the mine operators called the attention of the Spanish Government to the fact that competition with brimstone had become keen. Only about a third of the former pyrite sales have been recovered. Should the Spanish Government persist in placing any duty on pyrite exports, it is quite certain entirely to ruin Spain's American ore business, and seriously affect that with European countries, as there is in the neighborhood of two million tons of brimstone there, mined and ready for shipment, and exports abroad, already large, are growing. Any burden of duty imposed by Spain will overbalance the scales against pyrite, a situation that cannot be met. It is doubtful if the Spanish Government realizes this, and that a stopping or curtailment in exports means restricted mining, less employment of labor, or the mines closing altogether. As a matter of fact, there are a number of Spanish mines that have been unable to operate through lack of sales because of brimstone competition.

The export-tax matter is still under consideration, but probably will be settled soon with a very small export tax levied.

The pyrite companies are slowly recovering from the war conditions and the labor trouble which followed in 1919 and 1920, but find it inadvisable yet to distribute any dividends.

Sulphuric Acid

According to the United States Geological Survey sulphuric acid was produced in 30 states in 1920 to the amount of approximately 5,600,000 short tons, of 50° to 66° B., computed as 50° B. acid. The estimated value of this acid is $59,000,000. Production of the stronger acids amounted to 502,970 short tons, valued at approximately $10,600,000.

The yearly production for 1911 to 1921 is given below.

Year.	Production. Tons, as 50° B. Acid.	Value.
1911	2,700,000	$17,369,872
1912	2,950,000	18,338,019
1913	3,575,000	22,684,526
1914	3,800,000	24,479,927
1915	4,120,000	32,657,051
1916	6,300,000	73,514,126
1917	7,200,000	87,540,181
1918	7,450,000	Not determined
1919	5,402,000 (est'd)	.....
1920	6,040,000 (est'd)	69,600,000
1921	5,000,000 (est'd)	.....

Records of the Bureau of Foreign and Domestic Commerce show that 14,494 short tons of sulphuric acid, valued at $738,188, was exported from this country in 1920, and 5409 short tons, valued at $87,979, was imported. Exports in 1921 were 6407 tons valued at $317,720.

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The acid trade is depressed, owing to the fertilizer industry being in the doldrums. At present, 66° sulphuric acid is approximately $17 per ton. Until farmers' credits have been covered, and they are in the market again, little help can come from this direction. However, necessity will probably bring the farmers back into the fertilizer market in 1922. The iron and steel pickling is slowly coming back. Petroleum refineries are somewhat below normal, and the chemical industry has been greatly depressed. It is believed that 1922 will be on the whole an improvement over 1921.

Technology of Acid-making

In a series of papers in *Chemical and Metallurgical Engineering*[1] Andrew M. Fairlie presented an excellent review of new methods and equipment for the production of sulphur dioxide, precipitation of flue-dust, and introduction of nitrogen oxides in the chamber process for the manufacture of sulphuric acid.

In reviewing this series of articles it will be noted that the following recent developments in the sulphuric-acid industry have been considered:

1. A variety of new kinds of plant equipment, such as electrically driven acid-pumps, acid-valves and gas-blowers of various designs and materials, and electrical apparatus for the precipitation of dust, all of which have been put on the market with a view to supplanting established equipment used for the corresponding purposes, considered to be less efficient, less durable, or more expensive than the new.

2. All-masonry Gay-Lussac and Glover towers, interchamber towers, and a new type of sulphuric-acid chamber, water-cooled on its outside.

3. Two proposed types of nitration processes which dispense with lead chambers altogether.

4. A remarkably porous solid, "silica-gel," having peculiar adsorption properties, including the quality of being able to adsorb into its pores metallic salts in such a finely divided condition as to effect catalytic oxidation of sulphur dioxide, but whose development, as a catalytic agent, has not yet emerged from the embryonic stage.

The salient points of each kind of plant, or of plant equipment, have been briefly described in such a way that the reader may compare them and that those who have to build or equip sulphuric-acid plants may be assisted in making their choice.

Uses of Sulphuric Acid

Sulphuric acid is used for the following purposes: Dilute acid—that is, 60° B., 78 per cent. H_2SO_4, or weaker,—is used in the manufacture of

[1] 25, Nov. 9, 16, 23, and 30, 1921.

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superphosphates, ammonium sulphate, and sulphates of magnesium, aluminium, iron, zinc, and copper; in precipitating barium and calcium sulphate for chemical purposes; in the manufacture of various mineral and organic acids; in pickling sheet iron for tinning and galvanizing; in the production of copper, zinc, silver, nickel, and gold; for various types of galvanic batteries, storage batteries, electroplating; in the manufacture of ether; in making and purifying many organic coloring matters; in making starch, syrup, and sugar; and in numerous other chemical and metallurgical operations. Concentrated acid—that is, acid 60° B., 79 to 100 per cent. H_2SO_4—is used for purifying benzene, petroleum, paraffin oil, or other mineral oils; for manufacture of nitro-glycerin, pyroxylin, nitrobenzene, picric acid, and various other nitric compounds and nitro ethers; and in the manufacture of fatty acids by distillation. Fuming acid (oleum) is used principally for the manufacture of various forms of explosives, certain organo-sulphuric acids, and in fortifying weaker acids.

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TALC AND SOAPSTONE

By Frederick B. Peck

The talc industry in 1921 experienced a marked depression, in common with nearly all industries. The generally unfavorable trade conditions were further aggravated by the expansion of mill capacity which occurred in 1919 and 1920. This resulted in drastic price-cutting and severe competition among producers for the small amount of available business. In some instances prices were cut below the cost of production. New operators in general found great difficulty in introducing their product, although in one noteworthy instance a new producer was able to run his mill practically to capacity because of the demand due to the superiority of his product. Competition proved too severe for some of the smaller companies.[1]

MARKETED PRODUCTION OF TALC AND SOAPSTONE IN THE UNITED STATES (a)
(In short tons)

Year.	Talc.		Soapstone.	
	Quantity.	Value.	Quantity.	Value.
1914	151,088	$1,340,874	21,208	$524,213
1915	166,336	1,401,197	20,557	490,385
1916	193,909	1,762,842	19,652	490,961
1917	198,613	1,889,672	20,235	.....
1918	192,977	2,104,960	15,530	576,059
1919	168,339	1,822,512	16,504	530,163
1920	186,460	2,295,252	24,175	740,197
1921	(b)126,434	(b)1,821,451	.....	.....

(a) U. S. Geol. Surv. (b) Talc and soapstone combined.

The statistics of talc and soapstone production in the United States collected by the U. S. Geological Survey are now combined. The reason for this step is given as follows:[2]

The Geological Survey has often found that material classed by producers as soapstone should more properly be classed as talc, or vice versa. Recently the distinction has become more difficult because of the use of pure and massive talc and impure but dense soapstone for the same purposes—for example, for the cores of electrical resistance coils. Furthermore, some rock classed as soapstone is ground and the product goes under the name of talc. The inevitable changes in classification have made the figures of the production of talc and of soapstone for any one year not strictly comparable with those of other years.

[1] *Eng. Min. Jour.*, Jan. 21, 1922.
[2] *Min. Res. of the U. S.*, 1920, U. S. Geol. Surv.

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TALC AND SOAPSTONE MINED AND SOLD IN THE UNITED STATES, BY STATES (a)
(In short tons)

State.	1919.		1920.		1921.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Vermont	78,661	$665,652	86,489	$816,794	48,648	$438,534
New York	62,495	750,765	68,168	977,228	41,937	530,154
Virginia	17,663	542,022	21,715	729,767	17,721	601,878
Maryland	(b)	(b)	4,372	17,948	(b)	(b)
California	9,837	147,470	13,199	232,182	8,233	128,188
Pennsylvania	(b)	(b)	11,183	121,302	7,205	76,912
New Jersey						
North Carolina	2,602	76,158	2,267	75,474	731	17,048
Other States (c)	13,585	170,608	3,242	64,754	1,959	28,737
	184,843	2,352,675	210,635	3,035,449	126,434	1,821,451

(a) U. S. Geol. Surv. (b) Included under "Other States." (c) 1919: Georgia, Maryland, Massachusetts, Pennsylvania, Washington; 1920: Georgia, Massachusetts; 1921: Georgia, Maryland, Massachusetts.

The quantity of ground talc sold by producers in 1921 was 106,900 short tons, valued at $1,181,000, as compared with 178,500 tons, valued at $2,143,000, in 1920. A canvass of the producers made to determine the quantity of talc consumed in 1921 by different industries shows that the paper industry used 38 per cent. of the total and that the average value was about $10.60 a ton. Most of the supply was obtained from Vermont and New York. The paint industry, which requires a high grade of talc, used 23 per cent. of the total. Nearly all the supply was obtained from New York, and the average value was about $14.10 a ton. The roofing industry consumed 18 per cent. of the total and drew its supply almost entirely from Vermont. The requirements for talc used in this industry are not exacting, as is shown by the average value, which was only $8 a ton. The rubber industry used a large quantity of talc for filler and in 1921 consumed 9½ per cent. of the total. Vermont furnished most of the supply, which had an average value of about $9.50 a ton. The textile industry used about 4 per cent. as a filler for cotton cloth. The average value was about $9.40 a ton. Only 2½ per cent. of the domestic output was used for toilet powder, the demand for talc for that use having been supplied largely by imported material. California supplied most of the demand for domestic talc for this purpose, and the average value was $18.60 a ton.[1]

The latest figures available show that in 1920 the United States furnished about 65 per cent. of the world's supply and consumed about 68 per cent.

MARKET[1]

A large New York State producer reports, as is true in nearly all commodities, that many consumers of talc in 1920, fearing to be cut short

[1] U. S. Geol. Surv., press notice.
[2] *Eng. Min. Jour.*, Feb. 11, 1922.

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on their requirements, placed orders for considerably more material than needed on a normal basis. Before they could cancel, numerous shipments were made, and many concerns entered 1921 with an unprecedentedly large inventory. What they did not carry in stock they had obligated themselves to take. By friendly adjustment with producers, they were permitted to absorb in 1921 their commitments for 1920 delivery. Slow business during 1921 for these consumers compelled abstention from the market in many instances until late in the year. As a result, sales in 1921 were considerably below those in 1920, but there was a gradual improvement in volume after the month of June. One reason for the falling-off in sales is the large outlet for some grades in paper making. Labor troubles closed down many of the paper mills for a long period. Moreover, the lessened export of paper has contributed to a smaller demand for talc where used as a paper filler. Some producers have been compelled to shut down in consequence.

In the main, sales of talc are made direct to the manufacturer by the miner who mills his product at the mines. A little is sold also through brokers. Prices range from $12 to $14 a ton for New York talc. Sales in October and November of 1921 showed a considerable increase over the other months of the year. There is a disposition among consumers to postpone the making of contracts for future requirements.

One of the largest American producers (situated in Vermont) reports a trying year, which in comparison with 1920 makes a sorry exhibit. Business was confined entirely to domestic trade. Practically all of the product is sold direct to consumers, of whom over 80 per cent. are paper manufacturers, and most of the remainder rubber-tire manufacturers. It is sold finely pulverized. Three leading grades are produced, which differ only in color and degree of fineness. The whitest and finest is made from rock selected for color to make it as white as possible. It is ground to about 250 mesh. The medium and lowest grades are ground to about 200 and 160 mesh respectively from the average run of rock as to color. Packing is done mainly in paper bags, though some talc is put up in burlap.

During the first quarter of 1921 there was virtually no demand for talc. This was followed by a slight improvement in the second quarter, and the remainder of the year witnessed a fairly substantial recovery. The total business was about 50 per cent. in tonnage and 40 per cent. in value compared with 1920. A good share of 1920 business was covered by contracts, but no contracts were made in 1921, partly because buyers were disposed to purchase their moderate requirements for talc in the spot market and partly because the producers were not inclined to tie themselves up at the low prices prevalent, which were from 15 to 25 per cent. under those of 1920.

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Prices for talc held fairly firm throughout 1921, although buyers generally obtained concessions and were especially favorable to new competition which is promised by large interests in several quarters, especially in the roofing grade. Prices ranged from $7 per ton f. o. b. domestic mines on heavy-tonnage yearly contracts for the roofing trade, which uses the less pure grades, up to $50 per ton f. o. b. New York for the fine white gritless Italian grades imported for some paper making and the better talcum powders. The roofing-paper trades are estimated roughly to consume from 30,000 to 40,000 tons and a canvass of this trade indicates that the final quarter of 1921 was one of the best in roofing history, and warrants a confident outlook. Hence the low-grade talcs are practically assured of a good year in 1922.

Imports and Consumption[1]

The generally unsatisfactory condition of the industry was reflected in the imports of talc, which amounted to 22,911,226 lb. valued at $238,581, only 53 per cent. in quantity of those for 1920 and 54 per cent. in value. Toward the close of the year a Canadian producer dumped his surplus stock on our markets at a very low price. Thus the import statistics showed an increase during the last three months.

The demand for talcs of various grades is, of course, dependent upon the prosperity of the consuming industries into which talc enters. The largest markets for Vermont talc are in the paper, rubber, and prepared roofing industries. The poor condition of the paper and rubber industries in 1921 caused a severe drop in demand for Vermont talc. The prepared roofing industry was not as badly effected, but even here demand was far from normal.

Much New York fibrous talc is used in paint, and as the demand for paint was fairly good, New York producers of talc were probably in a somewhat better position. Toilet-grade talc is produced in quantity only in California, and California producers find their principal outlet for high-grade talc in the East. Heavy imports of low-priced high-grade talc from Canada, France, and Italy, and high transcontinental freight-rates, combined with a lessened demand, made it almost impossible for California producers to compete in eastern markets.

The tariff situation is still unsettled, though the Fordney Bill, which passed the House of Representatives, is regarded as affording ample protection to the talc industry. This bill provided for a tariff of ¼ ct. per lb. on the crude, ½ ct. per lb. on the ground, and 1 ct. per lb. on cut or sawed crayons, cubes, or other forms.

[1]Raymond B. Ladoo, *Eng. Min. Jour.*, Jan. 21, 1922.

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Despite the generally unfavorable condition of the industry, there were a few encouraging developments. For the first time the talc industry as a whole, through the Talc and Soapstone Producers' Association, embarked upon an advertising program. Though the publicity so far has been rather limited in extent, it is a very hopeful sign.

Return to normal conditions will probably find the talc production divided between fewer but relatively stronger companies. Few producers expect a rapid return to the unusually high production of 1920. Hence new mill construction will not be justified in the near future unless such mills represent a distinct advance in the art of milling, resulting in lower costs or better grades. Domestic production of talc of toilet grade depends primarily upon the extent of protection afforded by the new tariff bill, but is also influenced materially by freight-rates and labor costs.

IMPORTS INTO THE UNITED STATES OF TALC, GROUND OR PREPARED (POUNDS)
(Fiscal years ending June 30)

Source.	1915.	1916.	1917.	1918.	1919.(a)	1920.(a)	1921. (a)
Austria	807,364	.....	.....	.....	.....	44,092	721,600
Belgium	.....	.....	.....	.....	.....	.....	.....
France	4,845,928	8,586,686	5,599,605	43,132	325,665	3,668,893	2,061,186
Germany	86,400	.....	.....	.....	.....	3,502	1,643
Italy	13,819,223	14,347,386	13,298,942	980,778	1,915,430	9,238,698	5,938,540
England	57,792	.....	112,492	.....	.....	68,414	144,001
Canada	10,789,271	10,443,285	15,073,759	24,370,925	23,704,355	30,245,480	13,986,638
Other countries	5,189	.....	218,245	.....	.....	189,550	57,618
Total	30,411,167	33,377,357	34,303,043	25,394,835	25,945,450	43,458,629	22,911,226

(a) Calendar years.

Talc and Soapstone in Foreign Countries

Canada.—Talc was produced from the Henderson mine at Madoc during 1921 and a total of 7916 short tons was raised, all of which was milled in the plant operated by Messrs. Geo. H. Gillespie & Co., Ltd., of Madoc. The sales of the milled product to various points in Canada and the United States amounted to 7900 tons having a total value of $115,200 and comprising 2000 tons high-grade, 4000 tons medium-grade, and 1900 tons of low-grade material. The price obtained for the high-grade product was in the neighborhood of $22 a ton; medium-grade, $14; and low-grade, $8. Compared with the shipments in 1920, the sales in 1921 were considerably lower. At the time of writing returns had not been received from two or three small producers, but the amount produced by these companies would in any event be very small. The total output in 1920 was 21,671 short tons.[1]

[1] Prelim. Rept. Min. Prod. of Canada, 1921, Dominion Bur. of Statistics.

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Examination was made in 1920 of several talc properties in British Columbia.[1]

A deposit of massive talc, or steatite, that has been known for many years, is situated 3 miles west of Keefers Station on the main line of the Canadian Pacific railway. No talc has been shipped from this property, but the talc body has been exposed in several openings made for gold. The talc occurs as a band of green, massive steatite, enclosed in slates, the entire series being tilted into a vertical attitude and being much jointed and squeezed. Little of the talc comes out in the form of compact blocks of any size, the material breaking up into irregularly shaped pieces, with slickensided surfaces. As far as could be ascertained from an examination of the tunnel that crosses the talc body, the latter has a width of about 8 ft., and is bordered on both sides by about 25 ft. of more or less talcose slate (soapstone). The talc grinds to a soft, gray-white powder, that should prove suitable for the paper, paint, rubber, and roofing trades. The property is well situated for working, lying close to, and higher than, the railroad tracks. The present operators are B.C. Silica & Talc Co., Rogers Building, Vancouver, who mined only quartz during 1920.

A talc deposit on Wolf Creek, Victoria Mining Division, Vancouver Island, was visited and found to be working on a small scale. The property is situated 33 miles from Victoria, and about three-fourths of a mile from the track of the Canadian National railway. The deposit consists of a narrow band of gray-green talc schist, dipping about 60°. The talc zone is enclosed in slates, and the whole is considerably squeezed and crumpled. A tunnel has been carried 50 ft. along the talc body, and is reported to show 18 ft. of ore. The operator is W. G. Dickinson, 576 Dallas Road, Victoria, who has taken out about 300 tons of talc. This material was shipped to his grinding mill at Sydney, and ground for roofing purposes. The talc of this deposit is evidently an altered, coarse-grained schist, and contains an appreciable amount of dolomite; it grinds to a light-gray powder. The deposit carries no massive talc, suitable for cutting into slabs.

A small tonnage of talc has been obtained in recent years from deposits at Mile 92, near D'Arcy, on the Pacific Great Eastern railway, Lillooet Mining Division. All of the talc taken out has been utilized for surfacing roofing paper, the principal operator being the Pacific Roofing Co., Granville Island, Vancouver. The talc is gray-green in color, carries minute specks of disseminated bornite, and grinds to a soft, nearly white powder. It shows evidence of crumpling, and breaks up readily into thin layers.

[1] Sum. Rept., Can. Dept. of Mines, 1920.

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No work was done during 1920 on the steatite deposit near Vermilion Summit, Windermere Mining Division, but it is understood that the deposit has been found to extend beyond the limits of the original claim.

PRODUCTION OF TALC AND SOAPSTONE BY COUNTRIES
(In tons of 2000 lb.)

	U. S. (a)	France. (b)	Italy. (c)	Canada. (c)	Spain. (d)	Austria. (c)	Ger. Empire, Bavaria. (d)
1911	143,551	44,092	15,600	7,300	6,226	15,212	3,728
1912	159,270	60,629	15,800	8,270	(e)	(e)	3,551
1913	175,833	66,331	26,456	12,250	(e)	17,637	(e)
1914	172,296	(e)	24,777	10,808	(e)	(e)	(e)
1915	186,891	(e)	24,187	11,885	3,925	(e)	(e)
1916	212,961	(e)	30,294	11,810	1,062	(e)	(e)
1917	218,848	(e)	24,100	15,803	3,803	8,818	2,393
1918	191,477	63,459	19,146	18,190	3,668	.....	10,260
1919	184,843	39,242	18,942	18,642	3,335	.....	15,983
1920	224,290	.....	23,969	21,671	2,366	.....	23,085
1921	126,434	.....	23,148	7,916	.....	.....	.....

(a) Talc and soapstone. (b) Talc, soapstone and asbestos. (c) Talc. (d) Soapstone. (e) Statistics not available.

France.[1]—The principal deposits of talc in France are in the department of Ariège, which produces 85 per cent. of the French output. Important deposits are worked at Montferrier in the Pyrénées close to the Spanish frontier, and at Luzech. Other talc-producing localities include Luzenac near Cette and various places in the departments of Pyrénées-Orientales, Isére, Aude, Savoie, and Loire. There is also a small production from the island of Corsica.

India.—The output of steatite increased from 2135 long tons valued at £6498 in 1919 to 3681 tons valued at £10,585 in 1920.[2]

Italy.—The talc deposits of chief importance in Italy occur near Pinerolo, southwest of Turin. In this district there are many small mines and quarries. The rock obtained in hand-picked and broken into small sizes before being sent to the mill for grinding. It is worked cheaply on account of the use of water-power and cheap labor. The principal product shipped is high-grade ground talc and massive cut talc.[3]

Italian talc is fine grained, and is used mostly for toilet and medicinal purposes. Nevertheless, the production is large, amounting to 21,000 metric tons in 1921 and 21,745 tons in 1920. About two-thirds of the production is exported.

Properties

High-grade prepared talc may be divided into two classes, dependent upon use: (1) massive talc, used for lava gas-burner tips and electrical insulation, pencils, and tailors' chalk; and (2) ground talc used for toilet

[1] Imp. Min. Res. Bur., London.
[2] *Rec. Geol. Surv. of India.* 1922.
[3] Imp. Min. Res. Bur., London.

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powder. The mining and preparation of massive talc does not present special difficulties, and foreign competition is not a large factor.

The production of high-grade white talc suitable for the manufacture of toilet powder is a problem which requires considerable attention, according to R. B. Ladoo in U. S. Bureau of Mines *Reports of Investigations*. Until the last few years most of the toilet-grade talc consumed in this country was imported mainly from Canada, Italy, and France. A small, irregular production of white talc was obtained from North Carolina, Georgia, and Virginia, but this material fluctuated so greatly in quality and quantity that it was not largely used by manufacturers of high-grade toilet powders. Gradually a wall of prejudice against all domestic talcs grew up in the toilet trade, and has been fostered by people interested in the sale of imported talc in preference to domestic.

Aside from import duties, the principal point to be considered in meeting foreign competition is the comparative quality. A difference of a few dollars in the price of a ton of talc is of little importance to the manufacturer of toilet powder, for the cost of the talc is an unimportant part of the cost of a package of finished toilet powder. Since definite, standard physical tests for quality of talc are lacking, comparisons of quality are largely governed by personal opinion and prejudice. Some of the qualities demanded of talc for toilet powder are: pure white color, good slip, freedom from grit, fine grain size, and freedom from lime. Opinions of consumers differ as to the necessity for insisting on all of these qualities.

It is probable that lime is not as objectionable an impurity as has been sometimes claimed, for some Canadian talcs that are comparatively high in lime are imported and used in large quantities in this country. Another objection sometimes raised to some domestic talcs is that they tend to "ball up" or collect in small clots when poured out or shaken from a can. This is a property common to most very finely ground materials, and is, in a way, an index to fineness. If this property is objectionable it can be easily remedied, with a decrease in cost of production, by coarser grinding; but to most consumers extreme fineness is a virtue and not an objection. In the essential qualities of pure white color, freedom from grit, and fine grain size it is a well-established fact that the best California talcs equal or surpass the best imported talcs. In the debatable qualities of slip and freedom from lime some of the best California talcs equal some of the best imported talcs and in other ways excel imported talcs. Some of the largest consumers of toilet-grade talc have expressed complete satisfaction with high-grade California talcs and have used them regularly in preference to Italian talc.

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TIN

By Baliol Scott

Nineteen twenty-one was the most disastrous year that the tin miner has ever experienced, at any rate in recent memory. The average cash price for the year was £165. 5. 4. against £296. 1. 7. for the year 1920; that is to say there was a reduction in the average price of £131. What made matters worse was that this protracted slump which had continued more or less from the beginning of 1920 came upon properties which were already in a state of distress, and the year closed without any signs of alleviation in the situation.

Speaking generally, the situation affected tin producers in three ways. Rich and powerful producers, of which there are not many in the tin world, imitated the example of the big copper interests and decided that it did not pay them to squander their irreplaceable reserves of ore at what they considered was below an economic price. At the other extreme were the poor producers like those of Cornwall who were forced to shut down because they could no longer maintain the unequal struggle with prices; while in the intermediate position were the bulk of producers, chiefly the miners of alluvial tin who, realizing every possible economy, and in Malaya working for very small wages and in some cases temporarily for none at all, sought to keep their mines going until the depression passed. Unfortunately for them the depression proved much longer

MONTHLY AVERAGE PRICES OF TIN IN NEW YORK AND LONDON

Month.	New York.			London.		
	1919.	1920.	1921.	1919.	1920.	1921.
January	72.50	62.89	36.00	248.9 .11	376.12.9	199. 9.3
February	72.00	60.00	32.14	224.3 .4	395.16.6	166. 5.0
March	71.75	61.99	28.81	236.18.5	369.14.5	156. 0.6
April	72.26	62.20	30.40	225.6 .6	345.13.1	163.18.1
May	71.94	55.07	32.50	234.9 .5	295.3 .7	177. 8.3
June	71.19½	48.63	29.42	238.8 .1	250.18.6	167.10.1
July	70.39	49.37	27.66	253.5 .1	262.1 .6	164.10.7
August	63.78	47.69	26.30	271.8 .0	274.5 .10	155.16.4
September	55.81	44.62	26.68	280.4 .0	270.7 .3	156.15.0
October	55.62	40.64	27.66	279.4 .11	258.8 .8	156. 7.7
November	54.17	37.02	28.94	283.13.7	241.5 .7	158.18.0
December	55.06	34.15	32.49	314.5 .1	212.11.8	169.14.9
Average	65.54	50.36	29.92	257.9 .8	296.1 .7	165. 5.4

New York in cents per pound; London in pounds, shillings and pence per long ton.

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than they expected, and there is no doubt that the necessity of picking the eyes of mines in order to keep going has in many cases considerably depleted the world's reserves of stanniferous ground. This influence has been especially felt in Malaya and Nigeria.

Over the whole year hung, too, the depressing influence of the stocks held up in the East. Reference was made to these stocks in last year's review.[1] The figures then given were wholly inferential, but it has since been verified that they were not very discrepant from reality, and at the present time of writing in the middle of 1922 the existence and future of the remaining stocks are a constant preoccupation for the market. Further reference to the history of the Eastern Pool will be made in due course when the position in Malaya and the Dutch Indies comes to be discussed, but it may be mentioned here that the accumulation of tin in the Eastern Pool owned by the F. M. S. Government, the Netherlands Indies Government, the Billiton and Singkep companies, and the Straits Trading Company amounted in all to 19,138 long tons. In addition there were the stocks of Chinese tin, about which it is not possible to speak with the same certainty, but which at a fairly recent date were reported to amount to something like 6000 tons of metal.

Bad, however, as the situation was from the point of view of the invisible supplies, co-existing as they did with a steady weight of visible stocks, the most serious part of the situation was unquestionably the low level of consumption. The war has had the effect of shifting the center of gravity as regards tin-consuming industries more markedly than ever to the United States. Continental demand remained but a shadow of its former self, while industry in Great Britain was crippled by the great coal strike, the scars of which are not yet healed. When we turn to the imports into the United States, we get some measure of the adversity with which the metal had to contend. According to the Department of Commerce, imports of metal were 24,197 tons, which was barely half the average of the two years immediately preceding the war and considerably less than half the landings during the period of maximum requirement. The figures including tin content of ore are shown in the following table:

IMPORTS OF TIN INTO THE UNITED STATES

Year.	Pounds.	Value.	Year.	Pounds.	Value.	Year.	Pounds.	Value.
1908..	82,503,190	$23,932,560	1913.	104,282,230	$46,900,314	1918.	164,579,905	104,588,619
1909..	95,350,020	27,559,937	1914.	95,049,612	32,861,188	1919.	112,741,207	62,761,967
1910..	105,137,740	33,921,449	1915.	115,636,332	38,736,909	1920.	163,064,231	92,581,927
1911..	106,986,872	43,390,639	1916.	149,237,760	55,840,205	1921.	72,608,905	22,318,580
1912..	116,003,385	50,371,102	1917.	154,470,040	68,372,034			

[1] MINERAL INDUSTRY, 29, 661 (1920).

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Since October, 1921, America has again appeared as a large buyer and it only requires a continuation of the rate which has been maintained since that time to re-establish gradually an equilibrium between output and consumption. At the time of writing, this statement may perhaps be challenged, but the writer believes that were the reduction in output during last year fully recognized there would be more general acceptance of the statement.

Production

At the time of writing it is impossible to present official figures of output which are sufficiently complete to be of value, and it is doubtful in the present chaotic condition of world statistics whether it is not better as a general rule to study the position of supply from the point of view of statistics of shipment rather than of actual mine output. According to figures of the New York Metal Exchange the tin supplies last year are estimated at 80,660 long tons as compared with 108,900 tons in 1920, a decline of roughly 28,000 tons. Figures to which the writer has had access, however, indicate larger aggregates in both cases, as shown in the following table:

	Long Tons	
	1920.	1921.
F. M. S.	34,928	34,446
Banka	13,994	12,125
Billiton and Singkep	8,500	8,000
Siam and India	9,500	5,420
China	7,400	3,600
Australia	4,206	1,704
Nigeria	5,250	5,388
South Africa	1,526	832
Bolivia	29,542	17,698
Cornwall	2,915	700
Various	500	500
Total	118,261	90,413

It will be seen that while the aggregates are considerably larger the decline in supply is not very different. It must be borne in mind, too, that with the exception of Bolivia to some extent the decline has not been a voluntary one; in fact in a measure output has been stimulated by the willingness of the coolies in the East to work longer hours and for a remuneration which they would not permanently accept, as well as by a corresponding sacrifice on the part of tin mining companies themselves to work their richer ground in the effort to avoid closing down and the dispersion of their labor force. Consequently, a rise in the price of tin when it does come can have little effect in the way of stimulating output for a considerable time.

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For the sake of comparison, the following table of world's production in previous years is appended:

WORLD'S PRODUCTION OF TIN
(In tons of 2240 lb.)

	1915.	1916.	1917.	1918.	1919.	1920.
Malaya	46,766	43,870	39,833	37,370	36,867	34,928
Bolivia	21,794	21,145	27,858	29,280	28,926	29,542(e)
Banka	13,773	14,548	13,246	13,247	12,044	13,994
Siam	7,800(a)	8,998	8,765(c)	9,154(c)	8,835(e)	4,286(d)
Cornwall	4,968	4,697	3,936	4,000(c)	3,350(a)	2,915
Billiton, etc.	5,750	5,000(d)	5,500(a)	7,200(a)	7,500(a)	8,211
Nigeria	4,555	5,075	6,510	6,000(a)	5,000(a)	5,250
China	3,012(b)	3,800(a)	11,053(b)	8,680(b)	8,332(b)	11,487(b)
Portugal, Spain	.....	250(a)	750(a)	300(a)	300(a)	300(a)
Australia	2,312(b)	5,000(a)	4,940	4,747	4,331	4,206
South Africa	2,089	2,003	1,632	1,235	1,003	1,526
India	500(a)	900(a)	1,200(a)	1,000(a)	500(a)	1,250(a)
Total	113,319	115,306	125,223	122,213	116,485	118,695

(a) Estimated. (b) Shipments to Europe, Asia and United States. (c) Siamese official figures for the 12 months to end of March in each year. (d) Crude metal exports. (e) Reported Pacific Coast shipments.

The year 1921, as has been the case for so many years past, has brought us nothing in the way of discovery of new deposits or even modification of mining costs in the older ones. With the general deflation in world's prices, costs of winning have no doubt shown some lowering; but there are no improvements in sight technically or commercially to promise any improvement beyond this, and in many cases the economies that have been realized are as indicated above of a temporary character which must reflect eventually on the well being of the industry.

The only localities of which any reports of discoveries have reached the writer are from Morocco, where French interests formerly connected with platinum are believed to have been making investigation. The prospecting operations in German Southwest Africa have given negative results and so far as the writer is aware have been abandoned; and the fact that the Yukon Gold Dredging Co. after a careful study of the world conditions decided to place its dredges on the already worked areas of the Federated Malay States is further evidence of the difficulty in finding any fresh tin ground at the present day.

The Tin Pool

We may now turn to consider the record of the individual tin-producing countries, but before doing so it is necessary to refer somewhat in detail to the conditions under which the Eastern Tin Pool was created, the constituent parties, and any inferences which may be drawn from these premises as to its duration. To understand the position it is neces-

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sary to make some brief retrospect. The Government of the Federated Malay States has depended for many years for a considerable portion of its revenue, both direct and indirect, upon the tin industry, directly in the form of an export duty and indirectly as the chief industry of the country upon which other industries depend for their activities. Previous to the slump in 1920, the F. M. S. Government came to the aid of the miners by buying unsalable concentrates in 1914, shortly after the outbreak of the war, and in 1919 as a result of the slump after the armistice. On the second occasion the F. M. S. Government consulted with the Government of the Netherlands Indies and an informal co-operation between the two authorities resulted. Consequently, when the situation became once more very difficult for the miners and they called upon their Government again to intervene, steps were taken to approach the Dutch Government once more, and at a Conference on Feb. 28, 1921, the whole situation was fully discussed. As the question of attempting to valorize tin has been very widely discussed, it is perhaps worth while quoting shortly from the summary of the negotiations which was given by the late Managing Director of the Straits Trading Co., Mr. W. F. Nutt, early in the present year. In his statement, Mr. Nutt said:

Buying commenced for Government account on Jan. 5, 1919, at $118 per picul (133⅓ lb.) and ceased on Apr. 26 of that year at $100, two smelting companies being appointed as Government agents. The result was that large unsold stocks of tin were accumulated by the F. M. S. Government, and also by the Straits Trading Co. In March, 1919, at my suggestion, with the authority of Sir Arthur Young, who was then Governor of the Straits Settlements and High Commissioner of the Federated Malay States, I went to Batavia to confer with the Netherlands Indies Government, the scheme being to hold off combined stocks for a minimum price of $119. The scheme, though not entirely acceptable, was the means of reciprocal feeling between the two Governments on the question of tin stocks. The Netherlands Indies Government did not sell, so that nominally the position of the Eastern tin holders was sound and of mutual benefit to both Governments and the smelting interests. In July, 1919, the market reopened, and by the middle of August the whole accumulation of Straits tin had been disposed of to buyers at Singapore, with satisfactory results to both the F. M. S. Government and the Straits Trading Co. From August, 1919 to February, 1920, the tin market reflected high prices, demand was good, and the highest prices ever recorded for tin in the history of the world were reached—£422 in London and $212.75 at Singapore. Speculation seemed to be rife, and in March very violent fluctuations in the tin price took place, the movement being downward. Big drops in the sterling price took place, and the position seemed to be out of control. From January to March, 1920, the dollar bids for tin in Singapore were at high premium over the London parity, and there seemed to be no stability in the position. Big falls in the sterling price brought out large sales from the F. M. S. producers, and ore held against advances was unloaded, and demand showed signs of falling off. The market would not absorb the supplies coming forward, but the Straits Trading Co. continued, in accordance with its policy ever since its inception, buying ore daily, with the result

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that it soon found itself accumulating tin for which there was little or no demand. This condition was maintained for a considerable time, and the position was fraught with anxiety. During that time I kept the Government fully informed of the situation, and the miners sent a deputation to the Government urging upon them to take action similar to what they did following the armistice, and on Dec. 6, 1920, the F. M. S. Government became buyers of tin as before from F. M. S. ores at $110 per picul. The price was subsequently increased to $115, then reduced to $100, at which price Government buying ceased on Feb. 28, 1921. On Feb. 20, 1921, I saw Mr. A. B. Voules, the Acting Chief Secretary, F. M. S., and suggested that I should go to Batavia to endeavor to come to some agreement with the Netherlands Indies Government in the matter of accumulated stocks, and I also had interviews with his Excellency at Government House, Singapore, and with his written authority I sailed with Mr. George Penny for Batavia on Feb. 25, 1921, and on Feb. 28, 1921, at Bandeong, a conference was held, at which the now well-known Bandeong Agreement was arrived at in the matter of accumulated stocks of Straits, Banka and Billiton tin.

Bandeong Agreement.—Although as indicated above events have been gradually shaping towards concerted action by the chief tin-producing interests in the East, the Bandeong Agreement was the first formal undertaking to hold tin with a view to raising the price. As such it has naturally received widespread attention, since it constitutes at any rate in principle a valorization scheme which has often been advocated but never attempted in relation to the metal. At the Conference there were representatives of the Straits Trading Co. and the Eastern Smelting Co., representing besides the smelters the F. M. S. and Johore Governments, together with the representatives of the Netherlands Indies Government and of the Billiton Co. After a considerable discussion it was finally agreed that the combined accumulated stocks of refined tin should be held off the market for a minimum period of three months to the end of May, 1921, but that if the price of three months Standard tin in London reached the figure of £240 per ton during the minimum period, or a private offer were received by any of the contracting parties at the equivalent of that figure, the further continuance of the agreement was to be reconsidered. In the event of the market price not recovering to the limit named, the consideration of the further extension of the period was provided for. The total amount of tin thus pooled amounted to 19,138 long tons, the holdings being as follows: F. M. S. and Johore Governments, 9508 tons; Netherlands Indies Government, 4000 tons; Billiton Co., 2800 tons; Singkep Co., 150 tons; Straits Trading Co., 2680 tons. The Eastern Smelting Co. held no stocks of its own and apparently it did not subsequently acquire any. The Straits Trading Co., however, from time to time added to its stocks, possibly under the idea that the agreement insured an early recovery in price. The financial position, however, became difficult for the Straits Trading Co., and after the

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resignation of the Managing Director, Mr. W. F. Nutt, the further stock outside the pool, amounting to 1350 tons, was disposed of towards the end of the year at an average price of about £155 per ton.

Meanwhile the pooling agreement was renewed from time to time and this arrangement was continued on into the current year, but towards the end of April it was announced that the Billiton Co. had been released from the terms of the agreement to the extent of 1800 tons and the Singkep Co. to the extent of 150 tons, but as regards the other parties and the remainder of the Billiton holding the agreement was continued. Such is the position so far as the writer has been able to learn at the time of writing, so it would appear that the pool to the extent of 17,188 tons will be maintained until further notice is given of any withdrawal. What secondary arrangements may have arisen out of the agreement is not disclosed, but apparently the Straits Trading Co. negotiated the smelting of the whole of the Billiton output instead of only a moiety, and also secured some portion, reported to amount to 6000 piculs a month, of the Banka output. These arrangements naturally increased the amount of tin appearing as the Straits Trading Co.'s brand, a circumstance which may account for the increased sales of Straits tin which undoubtedly fostered the impression that the Pool was being quietly liquidated.

It is almost unnecessary to point out that the magnitude of the amount of tin pooled and the continuous discussion of policy and succession of rumors of liquidation exercised a very disturbing effect on confidence in the recovery of prices, and as this pool still exists the writer has thought it desirable to state the position as he understands it today at some length.

The Industry in Individual Countries

Malaya.—The export of tin from Malaya in 1921, contrary to the expectation entertained during a large portion of the year, showed but little reduction on the 1920 figures, despite the enormous fall in prices. The 1920 export of 34,928 tons showed a reduction of 5.4 per cent. on the corresponding figure for 1919, but in 1921 the output fell off only 1.27 per cent. with a total of 34,446 tons. There is little doubt, however, that the output during 1921 was obtained from a smaller number of mines, and that many of those which have managed to survive have only done so by stimulating their output. How long this forcing can continue is a matter of conjecture, but little development or dead work can have been done during the year, and sooner or later this must affect the future output.

During 1921 there was a general reduction in working costs, but the features in different cases vary so much that it is impossible to give any

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accurate figure of a general average. In addition to the difference in the values, depth of ground, working methods, and situation of the different mines, the disposition of the laborers has to be considered. The experience of the year showed that on Chinese-owned mines the coolies, rather than face entire unemployment, had been willing to work for bare board and lodging, and to suspend wages until better times.

As might be expected opinions vary as to the future course of production. At the meeting of the Straits Trading Co. early in the current year it was predicted that the 1921 output would be maintained and the export figures up to the end of April bear out that impression; but later opinion seems to be somewhat less confident. The President of the F. M. S. Chamber of Mines in reviewing the results of 1921 said that the majority of Chinese-owned mines, and some European mines, were now unable to make ends meet, and could not long continue with tin at its present price, so that it would appear that the output must decline. The same prediction had been made a year ago, but the positions then and today were very different. Costs had now been greatly deflated, and any further possible reduction was so small that it could not greatly affect the position. This was intensified by the forcing of the mines last year and the lack of development. Their costs were as low, if not lower, than any other tin-producing country of the world, so that everything appeared to point to a low world-output for the current year if prices remained down. While this reflection was consoling, they must not forget the large stocks that did exist, and the the only real cure for the present position is an improved consumptive demand and low working costs. He also said that on such information as he possessed, the average cost of production from an average mine owned by Chinese and worked by Chinese methods was between $80 and $85 per picul of metal, though many could produce for a limited period at from $5 to $10 under that price. Mines worked by European methods were most producing somewhat more cheaply. Generally speaking, wages fell from 15 to 20 per cent. during the year.

One feature which cannot be disguised is the steady and heavy decline in the number of coolies employed in the industry. One writer recently[1] gave the number of coolies at work at only about one-quarter that of the heyday of activity. As the coolies worked last year double tides and in many cases even without wages, it is quite impossible to look for any increase in output taking place rapidly should prices advance. The only prospects would be from an enlargement in the amount of wash handled mechanically and the possibilities in this direction appear to be distinctly limited. Considerable interest developed during the year in

[1] *Min. Jour.*, June 10, 1922, p. 437.

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the proceedings of the Yukon Gold Co., which after a lengthy prospecting campaign commenced operation with one dredge and the promise of further units going into commission during the current year. The same writer, however, does not appear to think that the increase from these new producers is likely to more than offset the decline indicated in production by manual labor, while the longer the strain of production to make ends meet at present market prices of tin continues, the severer will be the reaction in a year or two's time.

PRODUCTION OF TIN BY STATES (a)
(In piculs of 133⅓ lb.)

	1911.	1912.	1913.	1914.	1915.	1916.	1917.	1918.	1919.	1920.
Perak	437,339	477,240	493,753	479,621	466,634	457,660	414,000	387,750	371,722	371,848
Selangor	231,175	255,382	252,765	244,665	234,155	205,650	184,135	170,359	178,608	148,715
Negri Sembilan	29,230	29,071	36,821	35,900	20,900	15,240	12,328	16,246	14,761	11,710
Pahang	43,954	51,779	58,791	63,723	63,980	54,464	58,734	53,460	55,427	54,632
Total	741,698	813,472	842,130	823,909	785,670	737,014	669,197	627,815	620,518	586,905

(a) Exports of tin ore, the latter being calculated to its assumed metal contents, upon which duty is paid to the F. M. S. Government.

Siam.—It is much too early yet to obtain any production figures from the tin-producing districts of Siam. The concentrates, however, are shipped to the Straits Settlements for smelting, and according to import figures have shown a very considerable reduction on the rate of output of a few years since. It is impossible according to these statistics to distinguish absolutely between production from mines in Lower Burma and the Siamese side of the border, but according to these figures of import, which are presumably fairly complete, Siamese shipments were 4286 tons. These figures, it is true, show a big reduction on the estimate assumed in the tin article last year, but owing to the absence of official data only estimates of the Siamese production based on an assumed continuance of output at about previous levels have been possible for two or three years past, so it is probable that the 1920 output was considerably overestimated.

India.—Production from lower Burma appears to have maintained itself somewhat better than might have been expected. The Straits Settlements imports referred to in the preceding paragraph credit the various Indian points of shipment with 1620 tons of concentrates, or say 1134 tons of tin. This total checks very closely with a semi-official statement of exports given by Mr. Cyril Fox of the Geological Survey of India,[1] where the total of tin ore is given as 1610 tons. In view of the fact that it has been impossible for some time to produce wolfram con-

[1] *Min. Jour.*, May 13, 1922, p. 354.

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centrates from Burma at anything like current quotations, it would seem that the enterprise of the companies mining in Tavoy and Mergui has been redirected with some success to tin deposits; in fact the returns from the Tavoy district during last year were fairly steady. Unfortunately, however, the writer has this year not received any report from the Tavoy Chamber of Mines and under the circumstances any detailed statement of the fortunes of the industry in Lower Burma are wanting.

South Africa.—The low prices on the termination of the Government subsidy resulted in a marked decrease in the production from South Africa. The total was 1430 short tons of 65-per cent. concentrate, or say 830 long tons of metal.

China.—From China we have at present no internal data. Shipments of Chinese tin into the United Kingdom and the United States of America were returned at approximately 3600 tons last year, as compared with 7400 tons in the twelve months previous. Owing to the existence, however, of considerable stocks in Hongkong and at the mines these shipments do not give us any very accurate idea of what the production may have been. In March of the current year these stocks as near as could be learned were in the neighborhood of 6000 tons. The holding of stocks of China tin, however, either up country at the mines or in Hongkong, is no new feature, and stocks certainly existed at the end of 1920. To attempt any close estimate of production is obviously impossible, but it looks as if the production was not very far from the level which appears to be pretty constant for the Kotchiu mines, and possibly 7000 tons would not be very wide of the mark for 1921.

These mines were the object of ambitious schemes before the war, when a modern smelter as well as an extensive mill were erected. An account was recently published[1] of the installation of a pumping plant which would enable more work to be done in the dry season. The restricted supply of water for ore-dressing purposes has been on several occasions stated to be the factor of limitation in regard to the output of these mines. The writer has been informed on what should be reliable authority, however, that the mill and smelter has not proved equal to the lift required. It is also reported that the plants installed have so deteriorated as to be useless in their present state, and the buildings in which they were housed have fallen into disrepair. Readers of earlier articles will remember the interest displayed by the Straits Trading Co. and the efforts which they made to secure at any rate a portion of the concentrates for their extended works at Penang. One of their representatives who visited the mines last year fell ill and died there, and it seems doubtful in view of the ill success which has attended all attempts to secure a

[1] *Min. Jour.*, Apr. 8, 1922, p. 263.

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footing by outside agencies in this exclusive field whether any development on modern lines can be looked for, especially in the present unsettled condition of Chinese affairs.

Great Britain (*Cornwall*).—Nowhere was the tin depression felt more disastrously than in this the oldest tin-mining field—in fact the very cradle of the industry. Most of the mines struggled on until the end of 1920, but the beginning of 1921 brought about closure after closure of the remaining mines, so that in a short time the only property left working was the Giew mine operated by the St. Ives Mines, Ltd. This property contrived to keep working throughout the year, returning about 300 tons of concentrates. Elsewhere, however, but little mining was done, and the only production was from clean-ups from the dressing floors and such returns as were possible from the much-restricted resources of the streamers and such sporadic work as was done upon dumps, some of it in the nature of relief work. Some 3000 odd miners, making with their dependents in the neighborhood of 12,000 individuals, were rendered largely destitute, and despite various efforts for their relief endured severe privations, especially during the winter. Owing to the world-wide depression in mining, the usual alternative of the Cornishman, emigration to foreign fields, was impracticable and as no direct aid was forthcoming from the State the mining community passed through a very distressing time, and is still far from having recovered from their troubles even now.

The following well-known mines were forced to close down: Dolcoath, Tincroft, East Pool, South Crofty, Tresavean, Geevor, and Levant.

As one of the great difficulties in Cornwall was the heavily increased cost of pumping from mines which generally speaking are heavily watered, pumping operations generally had to be suspended, and these old and deep mines to a considerable extent filled up, so that managements are faced with the prospect of considerable expenditure before they can even begin cleaning up old workings or thinking about development, which owing to the long struggle against adverse circumstances will mean a big task before any regular mining operations can be safely re-commenced. The closing of East Pool was accelerated if not definitely caused by a run of ground in the main pumping shaft, and this in due course involved the closing of Crofty also, as the East Pool water was bound eventually to make its way into that adjoining property.

At East Pool it was finally decided to sink an entirely new shaft to the eastward of the cross course, and this work was begun early in the current year, a work which it is hoped to complete in 12 months' time. Developments in this newer part of the mine are said to have been so satisfactory that when the shaft and pit work are completed production

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should be possible forthwith, but what policy the Board may finally decide to adopt remains to be seen.

At South Crofty it was finally decided to increase the pumping plant to deal with the extra duty involved by the additional coming water, and after many representations and lengthy negotiations a loan of £30,000 was obtained from the Trade Development fund, but it is obvious that when the mine is drained an extensive program of development will have to be carried out before production can again be resumed on a permanent basis, and until the price of tin improves it is not likely that anything but dead work will be done.

In the St. Just district efforts have been made to give employment to as many men as possible, but operations on an economic basis are impossible for the present.

Owing to a provision in the new Mining Industry Act, output statistics from individual mines are no longer available for publication and it is, therefore, impossible to give figures of Cornish output until the Government report becomes available, which does not usually happen until the end of the year. So far, however, as the writer is able to judge from the scanty data available the output last year probably did not exceed 700 tons.

Australia.—Australia is another country where tin mining has been a diminishing industry for a long time past. Here as elsewhere where a considerable portion of the output is derived from lode mining the crisis was acutely felt and the output again fell off heavily. According to the statistics of the Australian Metal Exchange the production of metal amounted to 2985 tons compared with 4108 tons in the previous year, while the overseas shipments were only 1704 tons compared with 2968 tons in 1920. The fact that official reports from the various States have not yet been received makes general detailed comment impossible. So far as can be judged the alluvial companies, especially the dredges, were mainly responsible for what output was effected. Towards the close of the year the well-known Mt. Bischoff company in Tasmania closed down, though the smelter still continued to work.

The value of the New South Wales output, which is all we have at present for that State, fell from £250,343 in 1920 to £163,541 in 1921. The great decline evidenced is stated to be due to the restriction and in many cases cessation of operations on account of the low markets and high costs. The chief lode-mining field—Ardlethan—showed a decline from a value of £47,214 in 1920 to £12,240 in 1921. As might be expected the alluvial propositions appear to have maintained their production best. The Tingha division returned tin to the value of £57,161, the Emmaville division £52,532, and the Torrington division £21,142.

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In Queensland the output of black tin was 1050 tons compared with 1486 tons in the previous year. As some of the producers stacked their concentrates to await a more favorable market, it would seem probable that the output of metal was on a lower scale than the production figures. There seems to have been a fair amount of prospecting during the year, and it is anticipated that with a better market the output should recover somewhat. The mine with perhaps the best prospects appears to be the Sardine on the Kangaroo Hills field, which is stated to have ore reserves to the extent of 1000 tons of concentrates, with geological conditions favoring further discoveries. The reduction and dressing plant at Derek's Tin Mines was completed during the year, and though the battery was started up in June crushing was later on suspended. Further examinations continue to be made of the old Vulcan mine, which was unwatered in the first half of the year, but further development in the bottom level, 1400 ft., was unproductive and it was found too costly to keep the mine unwatered to this depth. Tributors, however, continue to operate at the intermediate levels and hopes are entertained of discoveries by lateral development. The dredges on the Stanthorpe field found profitable operations very difficult and several were closed down. The alluvial mines south of Cooktown also closed down and leased their holdings to tributors.

AUSTRALIAN TIN OUTPUT
(In long tons)

	1917.	1918.	1919.	1920.
New South Wales	1,781	1,698	1,776	1,600
Queensland	824	917	596	981
Victoria	93	88	74	60
Western Australia	266	270	207	165
Tasmania	1,846	1,579	1,580	1,310
Northern Territory	130	195	98	90
Total	4,940	4,747	4,331	4,206

Dutch East Indies.—The only statement as to production in 1921 available to the writer is that of Messrs. J. Blum, published in London at the end of January, which gave the production as 14,355 long tons, an increase on the previous year of 361 tons. A recent American consular report from Batavia gave the exports for 1921 as 13,539 metric tons. Messrs. Blum's figures of export, however, were as low as 12,125 tons. How far the excess of production over exports was accounted for by the Banka tin put into pool is not clear, but as the pool was arranged early in 1921, it rather looks as though there had been further accumulation of stock during the course of the year. Since the beginning of 1922 the

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Dutch authorities have decided not to publish any further figures of production.

The output from the Billiton mines continues on the enhanced scale of the last two or three years, and is probably due to a desire to obtain as much tin as possible before the concession lapses in 1927. The whole of the output is now sent to the Straits Settlements for smelting, from where it is placed on the market as Straits tin. The following figures furnished by the company show the outputs for the last 10 calendar years. The figures in metric tons have been calculated from the equivalent of 16.4 Java piculs = 1 ton.

Year.	Java Piculs.	Metric Tons.	Year.	Java Piculs.	Metric Tons.
1912.....	67,319	4,105	1917.....	105,123	6,410
1913.....	72,103	4,396	1918.....	112,452	6,857
1914.....	74,715	4,556	1918.....	116,692	7,115
1915.....	85,102	5,188	1920.....	126,871	7,736
1916.....	96,404	5,878	1921.....	128,970	7,864

The output of Singkep in 1920 was 608 metric tons, which was about the average of recent years.

Reports have been current this year that the Banka output would be decreased, but there seems no clear ground for this impression. At the Bandoeng Conference the Management intimated that they would continue output along the lines of previous budgets. Their most serious pre-occupation was the contracts for Chinese labor, and the ores obtained were sufficiently high grade to make the cost of producing tin a secondary issue.

Schemes which appear to have been entertained of centralizing all the Banka smelting at Tandjong Priok appear to have been temporarily suspended in view of the offers of the Straits Trading Co. for a certain portion of the output.

Bolivia.—It is several years now since any official statistics of Bolivian production have been forthcoming, and it is necessary to base conclusions in this matter on figures of shipment. This at once imports some uncertainty into the position. The Bolivian shipments last year showed a very great decline, falling from 29,542 tons to 17,698 tons. Such a decline naturally raises the inquiry whether output was not held back. This is a question which it is much easier to raise than it is to answer. A recent report by the British Consul in Bolivia suggests that one company accumulated stocks to the extent of 7000 to 8000 tons of tin, presumably barrilla, during the year. As no particular concern was mentioned the statement cannot be further examined. The writer, however,

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has had opportunity of discussing the matter with individual Bolivian producers and their agents, and finds that this figure is considered much too high. There seems to be no doubt that with the slump in the early part of 1921 output was very sharply curtailed. This had the effect of deflating labor demands and the position was further improved by the gradual depreciation of the boliviano, which declined from 1s. 7d. to about 13½d. in British currency, on the basis of which the bulk of the tin is sold. As a result, towards the end of the year when the London price was about £175 the Bolivian mine owner was receiving a price in Bolivian currency which would mean a London price of nearly £240 at the par rate of exchange. This circumstance alone would seem to favor the realization of any accumulation of supplies at the mines and since the beginning of 1922 Bolivian exports have been again on a much larger scale, probably at the rate of something like 25,000 to 26,000 tons per annum; this points either to a realization of mine accumulations or to an enlarged production, or to a combination of both, but at the present date it is impossible to say which influence predominates.

EXPORTATION OF TIN ORE FROM BOLIVIA
(In metric tons)

Year.	*Barrilla.* Tons.	Tin Contents. (*a*)	Year.	*Barrilla* Tons.	Tin Contents. (*a*)	Year.	*Barrilla.* Tons.	Tin Contents. (*a*)
1904..	20,369	12,221	1910.	38,548	23,129	1916.	35,097	21,145
1905..	27,690	16,614	1911.	37,073	22,434	1917.	46,420	27,858
1906..	29,370	17,624	1912.	38,378	23,027	1918.	48,801	29,281
1907..	27,678	16,607	1913.	44,594	26,756	1919.	45,648	27,389
1908..	29,938	17,963	1914.	37,259	22,355	1920.	49,237	29,542
1909..	35,566	21,340	1915.	36,324	21,794	1921.	29,497	17,698

(*a*) Tin content of the barrilla (black tin concentrate), computing the latter at 60 per cent. metallic tin.

It should be borne in mind that the chief producer, the Llallagua, did reduce output very much last year, concentrating apparently on development, and so far as the writer can learn this has borne fruit and production has again increased to something like 1200 to 1500 tons per month. The question is of especial importance to the American smelters in view of the extent to which they are dependent upon Bolivian supplies. In the past the American Smelting & Refining Co. has drawn the bulk of its supply from this great producer. Recently, however, a contract has been negotiated with the Williams, Harvey interests under which the latter will obtain the whole of the Llallagua output for three years.

Very large sums appear to have been spent by the American Smelting & Refining interests in Bolivia in the last few years with a view to obtaining more extended ore supplies. They examined a number of existing

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Peru.—In 1920 Peru produced an equivalent of 76 metric tons of 60-per cent. WO_3 concentrates.[1] The mining activity slackened considerably during 1921 and it is estimated that less than 25 tons was produced. The mineral is chiefly huebnerite and the important mining districts are Conchucos and Corongo. The Huaura deposits are considered very extensive. A part of the Peruvian tungsten shipments are of Bolivian origin.

EUROPE

England.—Since 1903 wolframite has been an important by-product of many English tin mines.[2] An approximate idea of English consumption of tungsten can be obtained by comparing figures of imports and re-exports.[3] In 1920 imports of tungsten ores into the United Kingdom totaled 6763 metric tons, of which 631 tons was subsequently re-exported, thus leaving for home consumption 6132 metric tons, 65-per cent. concentrates. Besides, 11,750 lb. of tungsten metal powder, 38 lb. of tungsten wire and 104 lb. of miscellaneous forms of tungsten metal were imported and retained. Of English produce the following quantities were exported in 1920: tungsten concentrates, 26 metric tons, tungsten metal powder, 554,740 lb.; wire, 682 lb.; tungsten metal in other forms, 464 lb.; ferrotungsten, 1245 metric tons. Imports of ferrotungsten in 1920 were but 4 metric tons, with no re-exports.

A detailed report of the tungsten industry up to the beginning of 1920 was published by the Imperial Mineral Resources Bureau.[4] The tungsten production of England for 1921 is estimated at 80 tons, largely as a by-product of the tin-mining industry.

Portugal.—For many years Portugal has been one of the chief tungsten producers in the world. Within recent years, however, the depression in the steel industry and the keen Chinese competition has been felt and the output of the Portuguese tungsten mines has dropped very materially. For years Portugal has furnished from 900 to 1600 metric tons annually. In 1920 the production fell to about 200 tons and in 1921 it is estimated at less than 150 tons. France's purchases amounted to approximately 700 metric tons of Portuguese wolfram concentrates in 1919. Some of the Portugal tungsten mines have been capitalized and operated by Americans. The principal mines are the Borralha in Tras Os Montes, the Panasqueira in Beira Alta, the Moimenta, the Montado de Adoria and Cabeco de Paredes. There are but few deep mines. The ore is generally associated with lead, zinc, or iron sulphides in the veins.

[1] *Estadistica Minera del Peru*, Lima, 1921.
[2] For details see MINERAL INDUSTRY, **29**, 687 (1920).
[3] *Comm. Rept.*, Oct. 17 and Dec. 19, 1921.
[4] The report can be obtained from H. M. Stationery Office, Imperial House, Kingsway, London, W. C. 2, England; price 1s. 2d., post free.

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Saxony-Bohemia.—The mining industry of the Erzgebirge, a range of mountains separating Saxony from Bohemia, received a severe setback. This applies in particular to the tungsten industry, which during the war had been very active as it was impossible to import ore from abroad. During the years 1914 to 1919 the output of concentrates averaged between 100 and 200 metric tons.[1] W. Venator has reviewed the mining situation in Saxony and points out the impossibility of encouraging tungsten mining in the face of the low charges for Chinese ores. Much of the Erzgebirge wolframite is associated with cassiterite. The output for 1921 we estimate at barely 50 tons of concentrates.

Spain.—The chief tungsten-producing provinces are Zamora and Badajoz. In the Province of Pontevedra considerable quantities of tungsten are recovered as a by-product of the tin-mining industry. As in other countries, the prosperity of the tungsten market is largely dependent upon the prosperity of the steel industry, and consequently the demand for tungsten concentrates was very low during the last two years. Towards the close of the year 1921 the market showed signs of improvement, but it was generally felt that further reductions in production costs were necessary before a definite revival of the tungsten industry would be possible. In 1918 Spain produced 580 metric tons of 60-per cent. concentrates and for 1921 the output is estimated at about 75 tons, derived principally from the tin mines. The new export tariff was put into effect. The duty on tungsten ores is 25 pesetas per metric ton.

Other European Countries.—France: The Department of Mines of France reported no output of tungsten ore during 1921.[2] *Italy:* Italy possesses wolfram deposits at Bedowina, Trentino, and scheelite has been mined on the Island of Sardinia since 1904.[3] For 1921 no production of tungsten has been reported. *Russia:* Tungsten occurs in various localities.[4] It has been practically impossible to obtain reliable production figures due to the disorganization of the Russian Mining Bureau. In 1921 the entire mineral production of Russia was less than 2 per cent. in volume of that of 1913. *Sweden:* Since 1918 Sweden has been turning out appreciable tonnages of tungsten concentrates. Wolframite and scheelite occur near Yxsjö in Bergslagen. Sweden's home consumption amounts to about 20 tons of concentrates per year in normal times. In 1920 Sweden produced 30.5 tons of tungsten ore valued at 74,736 kroner.

ASIA

Burma.—Burma, for years a rival of the United States as the largest tungsten producer, and whose output for the term 1916 to 1919 inclusive

[1] See MINERAL INDUSTRY, 29, 690 (1920).
[2] For tungsten localities in France see MINERAL INDUSTRY, 29, 689 (1920).
[3] A. Martelli, Rassegna Mineria, Torino, 54, 99–102 (1921).
[4] See MINERAL INDUSTRY, 29, 690 (1920).

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averaged between 4000 and 5000 tons of concentrates, passed through a very trying year. The total tungsten output in 1921 amounted to but 700 tons of 65-per cent. concentrates.[1] Next to the Chinese competition, the dislocation of the iron and steel industry in the United Kingdom on account of strikes seriously affected the tungsten mine shipments. At the close of the year producers were burdened with stocks for which there was little or no demand at reasonable prices.

The important tungsten centers are Tavoy, Mergui, Moulmein and Thaton; tungsten is also found in the Southern Shan States. The Tavoy lodes are usually quartz with a little mica. Cassiterite, pyrite, and other natural sulphides are usually associated with the wolframite. From a high-speed steel man's point of view the Burmese tungsten cannot compare in quality with that of Colorado (ferberite) or California (scheelite).

China.—The outstanding event in the tungsten industry of the world within the past ten years is the entrance of China as a tungsten producer. With the ready accessibility of her deposits, her very cheap labor and transportation, China has brought the price of tungsten ore down to such low levels that many of the heretofore important mines have been forced to suspend operation indefinitely. In 1915 China's tungsten shipments were nil; in 1918 they amounted to 10,200 tons, or twice as much as any other country had ever produced, and about one-third the entire world's output. The great mass of China's tungsten resources is as yet untouched. During 1921 Chinese tungsten was sold in San Francisco at $2.00 per unit, or $120 per short ton of 60-per cent. concentrates. The normal price in the United States during the period 1904 to 1914 averaged $380, or about three times China's low figure of $120 per ton. In Great Britain Chinese tungsten ores were sold in 1921 for as little as $93.00 per short ton of 60 per cent. WO_3. The tungsten deposits of China were the principal source of supply for export to the United States. During 1921, 988 tons of Chinese concentrate valued at $178,558 was delivered at San Francisco and other American ports; this was over two-thirds of the total foreign tungsten concentrates delivered.

Most of the tungsten deposits of China are alluvial and are worked in a small way by the owners of the land—principally farmers—the output being bought by export firms. Tungsten, associated with tin, occurs in the Provinces of Hunan, Kiangsi, and Kwangtung, particularly in the district which takes in all three of the provinces. Valuable deposits also occur in the Province of Chili.[2] China's total tungsten production for 1921 is estimated at 3500 metric tons, 60 per cent. WO_3.

[1] *Min. Jour.*, May 13, 1922.
[2] For further details, see MINERAL INDUSTRY, 28, 699 (1919) and 29, 693 (1920).

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Federated Malay States.—Wolframite and scheelite occur in the States of Perak, Selangor and Negri Sembilan. According to the latest report of the British Imperial Mineral Resources Bureau the production of the F. M. S. in 1920 totaled 234 metric tons of 65-per cent. concentrates, or about 254 metric tons on the 60-per cent. basis. On this same basis the production for 1921 is estimated at 80 tons, a further decided drop from the high figure of 1917 of 721 tons. Chinese competition, although at first not as keenly felt as by American producers, has been gradually forcing the less productive of the F. M. S. mines to close down. In September, 1921, there were exported from the States of Selangor 924 piculs (55 metric tons) of wolframite. This represents the output of the first nine months of 1921.[1] At Bukit Rumpian in Perak are some of the best-known lodes. Here the country rock is tourmaline granite traversed by small quartz veins carrying both tin and tungsten. Scheelite is found at Kanching and near the Batu caves.

Unfederated Malay States.—The British Mineral Resources Bureau in its report of September, 1921, credits the Unfederated Malay States, Kedah, Trengganu and Johore, with a total tungsten production of 1177 metric tons, 65 per cent. WO_3, for the year 1918, and 706 tons for 1919. Official figures for 1920 and 1921 have not as yet been published. The 1921 output is estimated at 75 metric tons, on the 60-per cent. basis.

As in other parts of the peninsula the small demand by British high-speed steel producers and the higher mining cost figures as compared with those for the mining of Chinese ores brought about a decided decrease in the year's total output as compared with 1918 or 1919. Mines are located on the Dungan River and in the Kemaman district, Trengganu, at Sintok and at Ayun, Kedah. Through Singapore and other Straits Settlement ports an equivalent of 800 metric tons of 60-per cent. concentrate was shipped in 1919 and 610 tons in 1920.[2]

Japan and Colonies.—During 1921 the Japanese tungsten industry received a further setback. According to the "Monthly Returns of the Foreign Trade of the Empire of Japan," the total 1921 production of the Empire and possessions amounted to only a few tons, 60-per cent. basis, as compared with 120 tons for 1920 and 1700 tons in 1918. Japan shipped no concentrates to the United States in 1921, whereas in 1920 114 tons was shipped and in 1919 756 tons. In Japan proper wolframite and scheelite occur in Yamaguchi Ken and in Ibaraki Ken. In Chosen ferberite is found at Kurasawa in the Province of Kai and huebnerite at Nishisawa in the Province of Shimotsuke.[3]

[1] *Comm. Rept.*, Feb. 4, 1922.
[2] *Comm. Rept.*, Supplement, 1922.
[3] For further details as to mining of tungsten in Japan see MINERAL INDUSTRY, 29, 695 (1920).

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Siam.—No official statistics have been published since 1917. The output for the last two years is estimated at about 40 metric tons.[1]

Other Asiatic Countries.—The production of the Dutch Billiton Island and that of French Indo-China have been practically nil in 1921. France has found it more economical to purchase Chinese ores.[2]

Australia and New Zealand

The tungsten mining industry throughout Australasia was practically at a standstill during 1921. The total production amounted to but an equivalent of 140 metric tons of wolframite and scheelite concentrates, as against 1550 metric tons in 1918. As pointed out by A. W. Ferrin,[3] inasmuch as Australian industrial prosperity depends largely upon exports, the collapse of the world market for metals entered largely into the cause of the mining depression, especially as the high basic wage-scale introduced during the war had not been correspondingly reduced, due to the fact that the cost of living remained high.[4]

The wolfram mines at Hatches Creek, Northern Territory, were in operation for a part of the year, but closed down definitely in October, 1921. During the war these mines furnished concentrates of high grade, but in the face of present Chinese competition the Hatches Creek mines, as well as other Australian tungsten mines, will remain practically idle for an indefinite period.

The King Island scheelite mines and mills are described at length in the *Proceedings of the Australasian Institute of Mining and Metallurgy.*[5] The treatment consists briefly in coarse crushing, tabling to remove such gangue minerals as quartz, and the recovery of a garnet-scheelite concentrate. The garnet is then separated electromagnetically.

The occurrence of tungsten in Northern Territory is described by Chief Warden E. Copley Playford.[6] The Hatches Creek tungsten field is situated about 700 miles from each of the termini of railway lines at Oodnadatta in the south and Katherine in the north. The nearest railroad connection east of the field is at Cloncurry, Queensland, 350 miles distant. In the Hatches Creek area are numerous wolfram-bearing quartz reefs, veins, and short irregular shoots from 1 in. to 4.5 ft. in width, with varying lengths up to 300 ft. The enclosing rocks are metamorphic sandstone, quartzite, conglomerate, slate, and schistose granitic rocks, the two latter being principally at the northern end, where

[1] As to tungsten localities in Siam see Mineral Industry, **29**, 695 (1920).
[2] For tungsten localities and geologic formations in these Dutch and French possessions see Mineral Industry, **29**, 691, 694 (1920).
[3] *Comm. Rept.*, July 28, 1921.
[4] For tungsten-producing localities of Australasia see Mineral Industry, **28**, 704–706 (1919) and **29**, 696–700 (1920).
[5] Melbourne, Sept. 30, 1921.
[6] *Chem. Eng. Min. Rev.*, Mar. and Apr., 1921; *Mining Mag.*, July, 1921.

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scheelite is the predominant mineral associated with gold. At the southern end of the field wolframite associated with oxide of iron, a little copper, and bismuth prevails. The deepest working to date is 117 ft. from the surface. Another important tungsten field, known as Wauchope Creek, is also situated in the Davenport Mountains about 60 miles north of Hatches Creek. Here occur a series of tungsten-bearing quartz reefs and leaders from 1 in. to 2 ft. in width outcropping for distances up to 800 ft. Mining operations have been of the nature of irregular open cuts. A great drawback throughout this area is the lack of sufficient water and labor. To date, or during a period of four years, 400 tons of 66- to 68-per cent. wolframite concentrates have been shipped from Wauchope Creek and Hatches Creek. In the latter part of 1921 the majority of the Wauchope Creek holdings were taken over by an Adelaide concern.

A detailed description of the mill of the Burma-Queensland Corporation at Wolfram Camp, north Queensland, was published by W. H. Bowater.[1]

There was an output of 4.5 tons of concentrates valued at £280 from Queensland in 1921, compared with 81.7 tons valued at £14,027 in 1920. In 1920 there was an additional production of 59 tons of bismuth-tungsten concentrate, valued at £4756, but there was no output of this material in 1921. The production in 1921 came entirely from the Chillagoe district, the mines in the Herberton district not being operated; it consisted of wolframite only.[2]

QUEENSLAND PRODUCTION OF TUNGSTEN CONCENTRATES (*a*)
(Metric tons of 65 per cent. WO_3)

Concentrates.	1919.		1920.		1921.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
Wolframite	228.5	£40,596	79.3	£14,275	4.5	£280
Scheelite	12.8	2,331	2.4	460	.....	.....
Bismuth-wolfram	139.9	18,681	58.7	5,814	.....	.....
Totals (*b*)	311.0	£52,267	111.0	£17,642	4.5	£280

(*a*) *Queens. Govt. Min. Jour.* (*b*) In deriving the total 65-per cent. WO_3 production the bismuth-tungsten concentrates have been taken as half tungsten, half bismuth.

AFRICA

Rhodesia.—Tungsten occurs in Southern Rhodesia as scheelite and wolframite. In 1907 the equivalent of 192 metric tons of 60-per cent. concentrates was shipped, but since then the industry has lagged far

[1] *Proc. Australasian Inst. Min. Met.*, No. 40, 1920; *Mining Mag.*, Sept., 1921; *Min. Sci. Press*, Dec. 1921. See under "Technology" below.
[2] *Queens. Govt. Min. Jour.*, Apr. 15, 1922.

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behind. In 1921 an equivalent of about 20 tons of concentrates, 60 per cent. WO_3, was produced, valued at $3893,[1] which is about the same as in 1920 and in 1919.

The Imperial Mineral Resources Bureau includes in its report published during the summer of 1921 a brief account of the tungsten deposits of Rhodesia and the Union of South Africa.[2] According to this report wolframite has been worked at Essexvale more or less continuously since 1905. Wolframite has also been found in the Sabi valley. Scheelite was first worked in 1906, near Gatooma, where it occurs in a quartz reef in gneissose granite. The reefs of the Essexvale tungsten deposits consist of greisen, composed chiefly of mica, fluorite, topaz, and secondary feldspar. The country rock is a coarse-textured and massive variety of hornblende granite.

Union of South Africa.—Scheelite is met with at many places, notably in the Stavoren tin mines, where some of the lodes are fairly rich; also near Leydsdorp, in the Transvaal, where the source of the mineral has not yet been traced, and near Stanger, in Natal. The tungsten production was practically nil in 1921.[3]

WORLD'S PRODUCTION OF TUNGSTEN ORES (a)
(Metric tons; 60-per cent. WO_3 concentrates)

Country.	1911.	1915.	1916.	1917.	1918.	1919.	1920.	1921.
North America:								
United States	1,035	2,120	5,400	5,574	4,573	845	196	7*
Mexico	.....	140	159	308	239	104	82*	75*
South America:								
Argentina	621	171	825	990	625	375*	130*	100*
Bolivia	336	850	3,288	4,215	3,700	2,160	300*	300*
Peru	52	412	532	427	256	144	76*	25*
Europe:								
England	264	360	427	265	325	183	102*	80
France	171	126	162	261	212	33	6	.....
Portugal	980	933	1,418	1,596	1,300	834	200*	150
Saxony-Bohemia	126	100	150	200	245	340	170*	50
Spain	96	500	440	525	580	365	150*	75
Asia:								
Burma	1,020	2,883	4,123	4,200	4,800	3,800	2,541	750
China	.....	.....	110	1,360	10,200	6,000	4,550*	3,500*
Fed. Malay States	186	329	524	721	362	550	254	80*
Unfed. Malay States	47	159	325	334	1,170	765	360*	.....
French Indo-China	39	333	343	433	450	280*	50*	75*
Japan and colonies	250	439	1,260	1,660	1,700	850	120*	.....
Siam	182	432	530	726	185	100	40*	40*
Australasia:								
New South Wales	465	100	310	268	280	250	50*	30*
New Zealand	165	249	310	235	197	167	42	15*
Northern Territory	65	36	137	252	275	130*	48*	60*
Queensland	700	640	460	471	358	337	120	25*
Tasmania	80	112	144	286	440	320	191	10*
Total world production	6,800	10,500	21,000	25,500	32,000	20,000	11,000	5,600

(a) Statistics reported by F. L. Hess of the U. S. Geol. Surv. and by foreign governments. The figures with an asterisk are preliminary estimates.

[1] *Comm. Rept.*, June 5, 1922.
[2] *Cf. So. Afr. Min. Eng. Jour.*, Aug. 27, 1921.
[3] *So. Afr. Min. Eng. Jour., loc. cit.*

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TECHNOLOGY

A very good account of the concentrating methods practiced by the Burma-Queensland Corporation at Wolfram Camp, North Queensland, was given by W. H. Bowater.[1] The new mill was put into operation in February, 1919. The ore is quartz in which the rich minerals occur in lumps and patches. The principal minerals are molybdenite, wolframite, bismuth and bismuth sulphide, bismuth carbonate, and rarely a little scheelite. The wolframite is friable and care must be taken to slime it as little as possible, and to crush the molybdenite as much as possible. The ore is delivered by rope tram, passes through grizzlies and crushers, thence to stamps at the rate of 5.5 to 5.8 tons per stamp per 24 hr. The pulp is automatically sampled before passing to hydraulic classifiers. Thence it passes through settlers and over Wilfley and Buss tables.

Three products are made by the concentrating tables: bismuth-wolframite concentrate, middling, and tailing. The concentrate assays 30 to 45 per cent. WO_3 and from 5 to 7 per cent. Bi. The middling assays about 8 to 10 per cent. WO_3, 5 per cent. MoS_2, and a little pyrite. The tailing runs 0.1 to 1.13 per cent. WO_3, the amount of MoS_2 varying according to the degree of fineness attained during crushing. The middling goes to Wheeler pans, hydraulic classifiers, and Krupp tables. The bismuth-wolframite concentrates are dried, sampled, weighed, and assayed, and then graded into 30, 16, and 12 mesh, and passed through the magnetic separator, of the Dalbouze bracket type. The product is a clean tungsten concentrate and a bismuth concentrate containing a little tungsten.[2]

A new method of separation of WO_3 from MoO_3 is described by Henry B. Merrill.[3] It consists in the extraction of MoO_3 from a mixture of the ignited oxides by means of a solution of 1 part of sulphuric acid and 5 parts of selenium oxychloride. Geo. S. Longley published his method of assaying for tungsten in the *Chemist Analyst* (April, 1921). It is a refinement of the standard hydrochloric-WO_3 method.

A patent was issued to C. J. Head of London[4] on his process for the production of metallic tungsten powder direct from sodium tungstate. Sodium tungstate is ground and mixed with ammonium chloride and a reducing agent, and the mixture is heated to 1100° C. The temperature is below the reducing temperature for manganese. Metallic tungsten in the form of a coarse powder is obtained, which is finally washed and graded. O. C. Buré[5] mixes the finely ground wolframite with fine coke

[1] *Mining Mag.*, Sept., 1921; *Min. Sci. Press*, Dec. 10, 1921.
[2] Bowater gives complete flow-sheet and detailed methods for assaying the products.
[3] *Jour. Am. Chem. Soc.*, 43, 2383–7 (Nov., 1921).
[4] Brit. Pat. No. 155,600.
[5] French Pat. No. 522,718, Aug. 5, 1921.

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or charcoal, about 25 per cent. by weight, and heats and reduces to a metallic mass containing tungsten, iron, and manganese. He subsequently treats this mass with chlorine gas at 1000° C., obtaining by fractionation a pure chloride of tungsten which is subsequently reduced to metal by hydrogen or water gas.

In Germany a carbide of tungsten under the trade name "volomit" was marketed. It has been used in place of diamond for rock-drilling.[1]

In Canada WO_3 is used as a catalyst in the commercial preparation of certain organic chemicals. It has also been found that tungsten metal has distinct catalytic effects in bringing about the formation of ammonia gas from its elements.

D. McFarlan Moore gave an account of his new tungsten arc lamps operating in an atmosphere of neon gas.[2] The lamps operate on 110-volt circuits. During the year 200,000,000 tungsten lamps were manufactured.

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[1] *Min. Jour.*, Sept. 3, 1921.
[2] *Trans. Illum. Eng. Soc.*, Sept., 1921.

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URANIUM AND VANADIUM[1]

By Richard B. Moore

Uranium

The production of uranium ores in 1921 was large. This was due to the demand for radium. This demand kept up fairly well during the early part of the year, but dropped very materially towards the latter part. A large amount of ore, however, had been mined and was being put through the plants, so that the production was large even though a considerable amount of radium was unsold by the producers. According to the U. S. Geological Survey, the output of uranium ores in 1921 was 8540 dry short tons of ore, with a content of 256,945 lb. of uranium oxide, valued at $682,505, which also contained 719,720 lb. of vanadium oxide, valued at $193,762; the total value of the ore being $876,267. The radium content was 32,964 milligrams. These values are largely hypothetical, because the companies that mined the ores also used them.

No pitchblende was produced during 1921, but the above production includes all of the uranium ores mined in the United States, including the uranophane from Lusk, Wyo., etc.

Operations during 1921 were mainly in the same districts that were mined in 1920. The carnotite belt has been extended to a small extent in a southerly direction. The Standard Chemical Co. has been getting a large part of its ore as usual from the Club Ranch and surrounding neighborhood. The company has, however, been producing a considerable amount of its ore from the south side of the Paradox Valley, west of the Jodandy claim. This is a district that was temporarily abandoned several years ago, but new beds of ore have been opened up, and production has continued.

Little was done around Thompson's during 1921. Operations around Temple Mountain, Utah, were closed down in August. A fair amount of development work has been done in this district, where the ore is high in vanadium, but rather low in uranium. A new district opened up during the year as an extension to the south of the proven fields is near the Carrizo Mountains, on the border of New Mexico and Colorado. Some fair ore showings have been found in this locality, and though the ore is not as high grade as further north, a fair production may be expected.

[1] Published by permission of the Director of the Bureau of Mines.

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Prices for ore have been approximately the same as in 1920. For several years it has been the custom to pay for the vanadium as well as uranium content. Recently on account of the slump in the vanadium market, prices on the vanadium content of the ore have been reduced, but prices for the uranium have been approximately the same as in the preceding year. These are as follows: 2 to 2½ per cent. U_3O_8, $2.25 per lb. of U_3O_8; 2½ to 3 per cent. U_3O_8, $2.50 per lb. of U_3O_8; 3 to 3½ per cent. U_3O_8, $2.75 per lb. of U_3O_8. Ore has been sold containing as low as 1 per cent. U_3O_8. Ore of this grade, however, has usually been high in vanadium. More recently, the tendency has been, owing to the lack of demand for vanadium, for the dealers to be less interested in the lower grades of carnotite ore.

Foreign Deposits

Some further information is available concerning the new deposits of uranium ores at Katanga, Belgian Congo.[1] The ore examined by the author in question is in the form of compact lumps. It has a density of 5.08, scratches calcite, in color is orange-red, and it includes grains of a black mineral several millimeters thick. On the outside, these lumps have the appearance of being the result of the alteration of cubic crystals that have been agglomerated; however, they are covered with a coating the color of which shades from yellow to yellowish green. One specimen analyzed 68.203 per cent. uranium oxide. The mineral appears to be a lead, calcium, barium, uranyl silicate. The author thinks that the mineral is mainly composed of uranotil, with the formula $(Pb, Ca, Ba)O.3UO_3$-$SiO_2.6H_2O$.

The deposit is near the town of Elizabethville, and is on the property of the Union Minière du Haut Katanga. Only a small amount of development has been carried out to date, but prospecting operations are being continued.

There have been no further developments in Canada in connection with the pitchblende deposits around Parry Sound, Ontario.

Reports have come from England to the effect that in the South Terras mine, Cornwall, a rich bed of ore has been struck. Some of this material extracted gave as much as 80 to 100 milligrams of radium per ton.

During last year a discovery of euxamite in Brazil was reported, but no detailed information is available concerning this reported discovery.

Uses

Uses for uranium are still needed. The demand is much smaller than the supply. Most of the radium operators do not recover their

[1] M. G. Buttgenbach, "The Uranium and Radium of Katanga," *Min. Sci. Press*, Nov. 5, 1921.

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uranium, but have designed their processes so that the radium and vanadium can be recovered, and the uranium can either be discarded entirely or can be stored in the form of a crude concentrate with the hope that some time in the future the demand for uranium will take care of the accumulated supplies.

VANADIUM

Owing to the slump in the automobile industry in 1921, the production of vanadium was seriously curtailed. The Vanadium Corporation of America closed its mine at Minasragra, Peru, early in the year. The last shipment of concentrates to the United States was about February, 1921, and no shipments have been made since that time, although considerable stocks of vanadium ore had accumulated in this country, and are still available. Business for a short time was better during the summer of 1921 than it had been during the Spring. This was especially true in July and August, but in the Fall there was another drop in the demand, and this was maintained until the first of 1922.

The Vanadium Corporation has for some time been giving special attention to the exploration of their mine to determine as far as possible the extent of the ore so that it could plan its work, and determine the future of the business. This has been done largely through diamond-drilling and the results so far have been very encouraging. It would appear that the reserves at Minasragra are sufficiently large to insure an ample production for many years. The grade of ore is naturally not so high as in the early days when the rich zone of patronite was being worked. More recently the average grade shipped has been from 20 to 25 per cent., and some ore has even dropped below 20 per cent.

It is planned to construct on the shores of Lake Pun Run a plant by which the grade of the product shipped can be increased very materially. The Vanadium Corporation has, in addition, a considerable amount of ore already mined, which it has not been able to export because of transportation conditions.

The Vanadium Corporation did not reopen its mines at Newmire, Colo., and there was no production of vanadium from roscoelite ore during 1921. In this country, the ores mined have been mainly in connection with the extraction of radium, and a considerable quantity of vanadium has been obtained from this source. No vanadium ores were mined as such in the United States during 1921. There were, however, 8540 tons of combined uranium and vanadium ore produced, which had a vanadium content of 719,720 lb., valued at $193,762. There were no radical changes in practice during the year in connection with the metallurgy of vanadium.

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According to Allen and Butler, of the University of Arizona Bureau of Mines (Bulletin No. 115), the only Arizona mine actually producing vanadium concentrates was the C & B, controlled by Wilson and Stone, of Christmas. This mine is in the Dripping Springs district, with Christmas as its shipping point. Most of the ore is vanadinite, averaging from 1 to 3 per cent. V_2O_5.

Prices

Prices during the Spring ranged from $5 to $5.75 per lb. of contained vanadium in the ferro, f.o.b. works. The variation in price depended upon the amount of impurities present, such as silica and like materials. There was a slight reduction during the summer, the price dropping to from $4.50 to $5 per lb. A number of lots of re-sale material have been sold at a price slightly under that quoted.

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ZINC

By Jesse A. Zook

The following comprehensive review of the zinc industry, by C. E. Siebenthal of the United States Geological Survey, gives concise comparisons of outputs and conditions in 1921 with those of 1920.

Mine Production of Zinc

The recoverable zinc content of ore mined in 1921 was about 250,000 short tons, as compared with 584,772 tons in 1920 and 549,242 tons in 1919. The output of the Eastern states was about 68,000 tons, that of the Central states about 168,000 tons, and that of the Western states about 14,000 tons, as compared with 102,242, 337,652, and 144,878 tons respectively in 1920. The loss in output of the Eastern states was one-third, that of the Central states one-half, and that of the Western states over nine-tenths. The upper Mississippi Valley region is credited with an output of about 4000 tons and the Joplin district with an output of about 164,000 tons. Oklahoma made the largest output, about 116,000 tons, twice as large as that of any other state. In 1921 Montana (the Butte district almost wholly) apparently produced about 11,638 tons, as compared with 91,906 tons in that district in 1920.

MINE PRODUCTION OF ZINC IN THE UNITED STATES (a)
(In short tons)

	Recoverable Zinc Content of Ore Shipped.				
	1919.		1920.		1921.
Arkansas		189		329	.....
Arizona		859		700	*Nil.*
California		236		583	529
Colorado		25,723		24,395	1,360
Idaho		7,997		13,966	17
Kentucky		36		9	*Nil.*
Joplin district: Kansas	47,636		61,069		
Joplin district: Oklahoma	178,410		219,188		
Joplin district: S. W. Missouri	31,468	257,514	24,422	305,679	164,000
Central and S. E. Missouri		72		19	.....
Montana		84,382		92,168	11,638
Nevada		4,502		5,349	35
New Jersey		92,912		77,371	56,447
New Mexico		3,797		5,300	114
New York		5,120		5,654	1,572
Tennessee		23,747		19,217	9,692
Utah		2,216		4,079	35
Washington				213	225
Wisconsin district: Wisconsin	40,765		27,286		
Wisconsin district: Illinois	6,788	47,553	4,720	32,006	4,000
Total		549,242		584,772	250,000

(a) U. S. Geol. Surv.

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Smelter Production of Zinc

The output of primary metallic zinc from domestic ores in 1921 was 198,232 short tons and from foreign ores 2268 tons, a total of 200,500 tons, as compared with 450,045 tons from domestic ores and 13,332 tons from foreign ores, a total of 463,377 tons, in 1920. In addition to primary zinc there was an output of 17,573 tons of redistilled secondary zinc, as compared with 21,371 tons in 1920, making a total supply of distilled zinc and electrolytic zinc in 1921 of 218,073 tons, of which 29,080 tons was high grade and intermediate, 47,814 tons select and brass special, and 141,179 tons prime western.

ZINC PRODUCED IN UNITED STATES (a)
(In short tons)

	1917.	1918.	1919.	1920.	1921.
Arkansas	25,660	26,753	31,437	31,481	15,278
Illinois	172,489	141,844	(b)118,340	(b)108,851	48,865
Kansas	76,048	29,149	43,942	41,044	16,573
Oklahoma	204,394	139,066	121,988	110,500	41,244
Pennsylvania	86,995	77,342	67,521	74,234	36,378
Other states	78,778	64,857	55,459	45,641	30,603
Electrolytic	25,209	38,916	27,056	51,626	11,559
Total primary	669,573	517,927	465,743	463,377	200,500
From domestic ore	584,597	492,405	452,272	450,045	198,232
From foreign ore:					
Australia	26,140	1,780	630	2,235	133
Canada	6,787	8,700	4,007	1,583	521
Chile	.....	886	751	536	.....
Italy	2,951	113	.....	.....	.....
Mexico	40,360	14,043	8,083	8,978	1,614
Spain	8,738	.....	.....	.....	.....
Total foreign	84,976	25,522	13,471	13,332	2,268
Total primary	669,573	517,927	465,743	463,377	200,500
Redistilled secondary	16,835	9,918	19,748	21,371	17,573
Total	686,408	527,845	485,491	484,748	218,073
Grade A	97,707	129,344	45,377	80,713	24,084
Grade B	69,189	68,987	39,173	33,893	4,996
Grade C	148,749	98,584	140,917	59,811	47,814
Grade D	370,763	230,930	260,024	310,331	141,179
Total	686,408	527,845	485,491	484,748	218,073
Average price per lb., cents:					
Grade A	14.0	11.1	8.3	8.4	5.6
Grade B	12.7	10.7	7.7	8.3	5.5
Grade C	9.4	8.0	7.2	8.2	4.9
Grade D	9.0	7.9	7.1	8.0	4.9
All grades	10.2	9.1	7.3	8.1	5.0
Total value of output	$140,027,000	$96,068,000	$70,882,000	$78,529,000	$21,807,000

(a) U. S. Geol. Surv. (b) Exclusive of electrolytic zinc made in Illinois.

Imports and Exports

The imports of zinc in ore decreased from 22,487 tons in 1920 to 2,705 tons in 1921, most of which was imported from Mexico. The zinc content of zinc ore in bonded warehouses on Dec. 31 was 14,292 tons, as compared with 25,650 tons at the end of 1920. Some of this ore may have been smelted but not shipped and thus may be included in smelter stocks.

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The imports of foreign slab zinc amounted to 6,674 short tons, as compared with 15 tons in 1920. Of these imports England furnished 4,200 tons, Germany 1,456 tons, Netherlands 560 tons, and Belgium 452 tons. The condition of the world market in the last 4 months of 1920, which permitted the sale in the United States of domestic zinc that had been previously exported, continued through the first quarter of 1921, during which period 731 tons of zinc was returned as against 8,162 tons in 1920. Not included in the imports given above are 6,529 tons of sheet zinc imported and entered for consumption in the first 9 months of 1921. But a few hundred tons of sheet zinc has been imported annually heretofore, and but a few tons since 1915.

The exports of zinc made from foreign ores were 640 tons and those of zinc made from domestic ores were 1753 tons, as compared with exports of 28,368 and 85,898 tons, respectively, in 1920. The exports of domestic zinc included in addition 1816 tons of sheet zinc, as against 11,852 tons in 1920.

ZINC ORE IMPORTED INTO THE UNITED STATES, IN SHORT TONS

Source.	1918.		1919.		1920.		1921.	
	Zinc Content.	Value.	Zinc Content.	Value.	Zinc Content.	Value.	Zinc Content.	Value.
Canada	5,173	$319,815	3,878	$115,974	1,794	$68,286	554	$14,453
Mexico	18,426	1,202,035	11,225	346,040	14,975	497,459	2,147	43,414
France	.....	.....	.....	.....	.....	.....	.....	.....
Spain	.....	.....	.....	.....	.....	.....	.....	.....
Italy	.....	.....	.....	.....	.....	.....	.....	.....
Australia	.....	.....	.....	.....	3,852	197,192	.....	.....
Other countries	1,210	52,119	1,906	67,476	1,866	74,315	4	833
	24,809	$1,573,969	17,009	$529,660	22,487	$837,252	2,705	$58,700

IMPORTS OF ZINC ORE AND ZINC DUST, IN SHORT TONS

	1913.	1914.	1915.	1916.	1917.	1918.	1919.	1920.	1921.
Zinc ore	31,416	31,962	158,852	344,611	188,925	63,305	43,437	58,726	6,731
Zinc content	13,497	12,132	57,669	148,147	72,474	24,809	17,009	22,487	2,705
Zinc dust	2,191	2,302	856	934	401	12	52	17	42

EXPORTS OF DOMESTIC ZINC ORE AND DROSS

Zinc ore	17,713	11,110	832	70	1,179	55	.....	.....	.....
Zinc dross	28	2,526	4,167	48	13,302	15,816	5,123	2,245	510

Market and Consumption

Early in January zinc concentrates containing 60 per cent. of zinc were selling in the Joplin district at $28 a ton, having dropped from $60 a ton at the beginning of 1920. The price dropped to $21 by the begin-

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ning of March, rose to $26 by the beginning of May, dropped to $21 by the middle of June and remained at that point until late in August, when it reached bottom at $20 a ton. Through the last quarter of the year there was a considerable improvement in price and at the end of the year concentrates were selling at $28 to $30 a ton.

It would be natural to suppose that zinc smelters, with Joplin concentrates selling for $20 a ton, would stock up fully. However, if the output of domestic primary zinc, 194,000 tons, is subtracted from the mine production of recoverable zinc, 250,000 tons, 56,000 tons is left to furnish the zinc content of pigments. But pigments made in 1920 contained 110,695 tons of zinc, and the output of pigments in 1921 was only one-third less than that of 1920. Apparently, therefore, smelter stocks of concentrates were depleted rather than increased in 1921.

The lack of demand led to considerable storage of concentrates at mines, and the stocks of concentrates in the Joplin district are estimated at about 70,000 tons and those in the Upper Mississippi Valley region at about 25,000 tons, figured as 60-per cent. concentrates. Stocks in other districts would probably bring up the grand total for the country to 150,000 tons. Even so, this quantity is small in comparison with the stocks of Australian zinc concentrates, which were reported a little while ago as 700,000 tons, containing about 47 per cent. zinc. The Rhodesia Broken Hill district of Africa is credited with stocks of zinc ore amounting to nearly 50,000 tons.

CONSUMPTION OF PRIMARY ZINC IN THE UNITED STATES (a)
(Short Tons)

	1915.	1916.	1917.	1918.	1919.	1920.	1921.
Supply:							
Stock, Jan. 1:							
In bonded warehouses	111	32	90	32	.....	.....	.....
At smelters	19,984	14,221	17,508	53,689	41,241	36,793	71,037
Production:							
From domestic ore	458,135	563,451	584,597	492,405	452,272	450,045	198,232
From foreign ore	31,384	104,005	84,976	25,522	13,471	13,332	2,268
Imports	904	684	257	35	70	8,177	7,470
Total available	510,518	682,393	687,428	571,683	507,054	508,347	279,007
Withdrawn:							
Exports, foreign, from warehouse	12,776	43,230	64,680	20,069	12,256	28,132	1,256
Exports, foreign, under drawback	255	.....	1,588	6,337	4,533	237	130
Exports, domestic	118,603	163,137	153,796	80,244	129,508	85,898	3,569
Stock, Dec. 31:							
In bonded warehouses	32	90	32	.....	.....	.....	131
At smelters	14,221	17,508	53,689	41,241	36,793	71,037	70,321
Total withdrawn	145,887	223,965	273,785	147,891	183,090	185,304	75,407
Apparent consumption	365,438	458,428	413,643	423,792	323,964	323,043	203,600

(a) C. E. Siebenthal and A. Stoll, U. S. Geol. Surv.

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At the end of December 42,400 retorts were reported in operation out of a total of 127,048 retorts, as compared with 36,000 out of 123,528 on June 30, 1921, and with 56,197 out of 158,625 at the end of 1920.

The average quoted price for prime-western zinc for immediate delivery at St. Louis in 1921 was nearly 4.7 cts. a lb., as compared with an average selling price for all grades of 8.1 cts. in 1920. The price of prime-western zinc began the year at 5.6 cts. in the St. Louis market, but had declined nearly to 4.6 cts. by the middle of April. After a slight recovery the price continued to decline until 4.25 cts. was reached at the midyear. After remaining practically stationary for three months, the price rose through the last quarter of the year and closed at about 4.7 cts. From the middle of May until the last of October the average weekly quotation for prime-western zinc was lower than that for lead.

The two largest zinc rolling mills have added zinc shingle machinery to their equipment. This use of sheet zinc is one of the most promising now being developed.

MONTHLY AVERAGE PRICE OF ZINC SLABS (a)

	St. Louis.				London.			
	1918.	1919.	1920.	1921.	1918.	1919.	1920.	1921.
January	7.661	6.922	9.133	5.413	54.000	56.045	58.643	25.262
February	7.639	6.273	8.708	4.928	54.000	46.150	61.338	24.850
March	7.286	6.150	8.531	4.737	54.000	38.500	53.467	25.077
April	6.715	6.114	8.184	4.747	54.000	36.188	47.388	25.530
May	7.114	6.079	7.588	4.848	54.000	35.477	45.088	26.923
June	7.791	6.551	7.465	4.421	54.000	36.763	41.193	26.750
July	8.338	7.523	7.720	4.239	54.000	41.815	41.886	26.262
August	8.635	7.439	7.835	4.186	54.000	39.338	41.220	25.068
September	9.092	7.160	7.661	4.235	54.000	40.955	39.690	25.256
October	8.451	7.473	7.150	4.605	54.000	43.630	39.756	26.315
November	8.141	7.827	6.247	4.665	54.100	46.588	35.028	25.949
December	7.813	8.350	5.824	4.837	56.050	53.101	27.762	26.900
Year	7.890	6.988	7.671	4.655	54.180	42.879	44.372	25.845

St. Louis, cents per pound. London, pounds sterling per long ton.
(a) *Eng. Min. Jour.*

AVERAGE PRICE OF ZINC SHEETS
(In Cents per Pound)

	1917.	1918.	1919.	1920.		1917.	1918.	1919.	1920.		1917.	1918.	1919.	1920.
Jan.	21.00	19.00	13.00	12.20	May	19.00	15.00	10.00	12.50	Sept.	19.00	15.00	10.50	12.50
Feb.	21.00	18.00	11.36	12.50	June	19.00	15.00	10.00	12.50	Oct.	19.00	15.00	10.50	12.50
Mar.	21.00	15.00	10.40	12.50	July	19.00	15.00	10.40	12.50	Nov.	19.00	15.00	10.78	11.67
April	20.44	15.00	10.00	12.50	Aug.	19.00	15.00	10.50	12.50	Dec.	19.00	15.00	11.15	11.50

Average for the year 1917—19.62 cents, 1918—15.58 cents, 1919—10.72. cents, 1920—12.33 cents.
NOTE.—These are base prices for ordinary-size sheets, in carload lots, f.o.b. LaSalle-Peru, Ill., less 8 per cent. discount.

The output of electrolytic zinc in British Columbia in 1921 is given as 26,500 short tons, as compared with 16,798 tons in 1920. The zinc

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smelter output of Belgium in 1921 was 73,270 short tons, as against 92,880 short tons in 1920. The world's smelter output of zinc in 1921 is estimated at about 450,000 metric tons, of which the United States smelted 45 per cent., as against a little over 700,000 metric tons in 1920, of which the United States smelted 60 per cent.

The Burma Corporation has discontinued plans for a zinc smelter for the present. Half of the Risdon (Tasmania) electrolytic zinc plant, which has a rated capacity of approximately 20,000 short tons, was started in December, 1921. It is expected that the other half will be completed by the end of 1922. As a result of the award of the League of Nations, Poland will make 86 per cent. of the production of zinc ore and 77 per cent. of the production of lead ore and will have practically all the zinc and lead smelters of Upper Silesia.

The following table gives the figures of United States zinc production as published by the *Engineering and Mining Journal*, differing but slightly from the foregoing figures of the Geological Survey. The figures below for 1920 and 1921 were collected by the American Zinc Institute.

PRODUCTION OF ZINC
(In Tons of 2000 Lb.)
By Ore Smelters Only

States.	1916.	1917.	1918.	1919.	1920.	1921.
Arkansas	7,637	25,701	26,750	31,396	29,966	14,917
Colorado	8,908	7,735	3,897	2,779	1,682	1,200
Illinois	181,495	176,071	141,808	118,631	109,483	52,183
Missouri-Kansas	154,396	86,505	31,834	43,347	25,131	31,784
Oklahoma	169,064	204,587	143,371	119,454	97,690	36,644
Electrolytic	10,963	27,245	38,885	25,962	57,441	11,553
East and others	147,555	154,567	138,805	130,115	158,379	67,333
Totals	680,018	682,411	525,350	471,684	479,772	215,614

Rolled Zinc

The output of rolled zinc in the United States in 1921 fell off nearly one-half, as shown by reports made to the United States Geological Survey by producers.

The market quotation on rolled zinc, in mill lots at the smelters, at the beginning of 1921 was 11.5 cts. a lb., with the usual discounts, but the quotation declined to 8.50 cts. a lb. at the close of the year.

The notable feature of the year in the rolled-zinc industry was the importation of large quantities of sheet zinc, for only a few tons had been imported each year since 1915. From April 1 to June 30, 1921, there was imported and entered for consumption 4,245 tons of sheet zinc, having a declared value at the foreign mills of $277,830, or 3.27 cts. a

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lb. In the first quarter also the imports were large, but during the last half of the year they were very small. The declared valuation in the last half of the year was larger by 2 to 3 cts. a lb., and at the same time the domestic price fell off 3 cts. from the price at the beginning of the year, so that at the close of the year the price of American sheets was less than that of the foreign.

ZINC ROLLED IN THE UNITED STATES (a)

	1919.	1920.	1921.
Zinc sheets:			
Quantity (pounds)	56,514,868	56,812,989	28,580,904
Value	$6,023,773	$6,625,660	$2,844,406
Boiler plates and special sheets:			
Quantity	5,083,137	3,950,489	2,545,755
Value	$521,389	$402,035	$192,987
Zinc strips:			
Quantity (pounds)	46,995,742	45,704,052	29,673,527
Value	$4,902,407	$5,262,538	$2,902,815
Total rolled zinc (pounds)	108,593,747	106,467,530	60,800,186
Total value	$11,447,569	$12,290,233	$5,940,208
Rolled zinc exported:			
Quantity	39,524,516	23,704,197	3,631,647
Value	$5,212,002	$2,832,993	$425,618
Available for consumption (pounds)	69,069,231	82,763,333	70,543,784

(a) Compiled by C. E. Siebenthal and A. Stoll, U. S. Geol. Surv.

SECONDARY ZINC RECOVERED

	1920, Short Tons.	1921, Short Tons.
Zinc recovered by redistillation	21,371	17,573
Zinc recovered by remelting, sweating, etc.	21,479	16,260
Total zinc recovered unalloyed	42,850	33,833
Zinc recovered in alloys other than brass	7,650	5,840
Zinc recovered in brass (estimated)	65,000	38,627
Zinc dust made from zinc dross	1,061	755
Estimated quantity of zinc dross used for dust	1,400	1,050

The zinc pigments marketed in the United States in 1921, as reported by producers to the United States Geological Survey, are shown in the following table. A general falling-off in the sales and in the average price of these products is shown in 1921 as compared with 1920, the greatest decrease being in the sales of leaded zinc oxide.

Zinc oxide and leaded zinc oxide are made after the American process directly from ore by sublimation in an oxidizing furnace, but some zinc oxide is made in this country by the French process, in which metallic zinc is sublimated in an oxidizing furnace. Lithopone and zinc salts are made by chemical processes, the zinc base being derived from zinc ore, metallic zinc, galvanizers' ashes, or scrap zinc. Lithopone is made by mixing equivalent portions of solutions of zinc sulphate and barium sulphide, which brings about a mutual precipitation of zinc sulphide and barium sulphate either in chemical combination or as a very intimate mixture.

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ZINC PIGMENTS MARKETED IN THE UNITED STATES (a)
(In Short Tons)

Pigment.	1919.		1920.		1921.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Zinc oxide	117,639	$20,591,877	99,444	$17,859,736	74,329	$11,231,716
Leaded zinc oxide	27,591	4,009,024	30,460	4,467,532	16,103	2,092,320
Lithopone	79,619	10,111,210	89,373	12,484,924	55,016	6,681,563
	224,849	34,712,111	219,277	34,816,193	145,448	20,005,599

(a) U. S. Geol. Surv.

Zinc Dust

The zinc dust produced in the United States in 1920, as reported to the U. S. Geological Survey by 12 plants, showed an increase in 1920 as compared with 1919 of over 70 per cent. in both quantity and value, but fell to a very low figure in 1921.

ZINC DUST PRODUCED IN THE UNITED STATES

	1919.			1920.			1921.		
	Quantity (Short Tons).	Value Based on Sales.	Average Price per Pound.	Quantity (Short Tons).	Value Based on Sales.	Average Price per Pound.	Quantity (Short Tons).	Value Based on Sales.	Average Price per Pound.
Prepared "blue powder"	4,083	$801,366	9.8	9,066	$2,009,117	11.1	2,006	$333,390	8.3
"Atomized" zinc dust	2,515	524,694	10.4	2,273	512,833	11.3	789	120,231	7.6

Zinc Mining in the United States

Arizona.[1]—As the demand for zinc was poor and the price decreased to about 5.11 cts. a lb., no zinc ore was shipped from mines in Arizona. The Arizona Hillside property in Yavapai County was idle.

Colorado.[1]—Colorado mines in 1921 produced 2,720,000 lb. of zinc, a decrease of 46,070,742 lb. Leadville was affected seriously by the low prices of zinc. It is proposed to equip the Yak mill with flotation methods for treating the zinc-lead-iron sulphides of those properties. The A. V. smelter operated three furnaces thoughout the year, but the Western Zinc Oxide plant was idle from early in the year until November, only half its furnaces being in operation at any time.

The United States Zinc Co.'s zinc-oxide plant at Blende was operated until June 3, when it closed, but it was reopened in December to treat stock ore and small shipments from Leadville. The Ohio Zinc

[1] U. S. Geol. Surv.

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Co.'s zinc-oxide plant and the Empire Zinc Co.'s zinc-oxide plant (new in 1920) and its zinc-lead-pyrite separation mill, all at Canon City, were idle. The River S. & R. Co.'s matting and volatilization plant for the treatment of zinc-lead-copper ores at Florence was idle until December, when it reopened on stock ores.

Idaho.[1]—No zinc ore was shipped from Idaho in 1921, though the output of recoverable zinc in 1920 was 27,932,326 lb. The Callahan Zinc-Lead Co. confined its operations to development work, and from the Morning mine only silver-lead products were shipped. The decrease in the price of zinc to about 5 cts. a lb. and the high freight-rates prevented the profitable mining of zinc ore.

Montana.[1]—The output of recoverable zinc in Montana decreased from 184,337,786 lb. in 1920 to about 23,275,966 lb. in 1921. The value of the output decreased from $14,931,361 to about $1,163,798. No zinc concentrate was shipped to Eastern zinc plants, but the electrolytic zinc plant near Great Falls was partly operated on silver-lead-zinc ores from the Anaconda Co.'s mines at Butte. The Butte & Superior and the Emma mines were idle, and the Elm Orlu mine produced zinc ore only during January and February.

Anaconda resumed operation in its zinc department in May, 1922, at full capacity, producing at the rate of 5000 tons of electrolytic zinc per month.

Purchase of the Silver Dike mine, in the Neihart district, by the American Zinc, Lead & Smelting Co., was closed in the spring of 1922, closing a year's option, during which time development work disclosed about 500,000 tons of silver-lead-zinc worth from $10 to $13 per ton.

Nevada.[2]—No zinc ore was mined in Nevada in 1921, though the production of zinc was 10,698,040 lb. in 1920. It was not profitable to ship zinc ore to Eastern smelters on account of the high freight-rate and the decreased price of zinc. The Consolidated Copper Mines, at Ely, and the mines at Goodsprings, large zinc producers in 1920, were idle in 1921.

New York.[3]—The Northern Ore Co., of Edwards, reopened in the spring of 1922 the plant and mines closed for a year. The plant started on a schedule of 40 tons of zinc concentrates daily, with expectations of doubling the force by mid-summer. Shipments from stocks accumulated during 1920 and 1921 continued during the time the plant was down.

New Mexico.[1]—The total production of zinc concentrates in 1921 was 228,000 lb. against 10,013,580 lb. in 1920.

The zinc mines at Hanover continued development work, but shipped

[1] U. S. Geol. Surv.
[2] U. S. Geol. Surv.
[3] *Eng. Min. Jour.*

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no ore. The zinc and lead mines at Kelly were closed early in 1921 after making only a few small shipments. The Grubnau Chemical Co.'s zinc-oxide plant at Waldo was operated part of the year on ores from Mexico.

Tennessee.[1]—The mine production of zinc in 1921 was 19,384,000 lb., approximately half of the output in 1920.

Most of the zinc produced was obtained from the Embree mine, in Washington County, and the Mascot mine, in Jefferson County, as the mines of the Union Zinc Co. in Union County, of the Tennessee Zinc Co. in Claiborne County, and of the Grasselli Zinc Co. in Jefferson County were idle.

The Embree Iron Co. operated the Embree mine, which produces zinc-carbonate and lead-carbonate ores. Part of the zinc ore is shipped directly from the mines, and part is concentrated by means of log-washers and tables. The dried crude zinc ore and concentrates contained 41.76 per cent. of zinc.

The American Zinc Co. of Tennessee continued its steady operation of the Mascot mine. The sulphide ore was hoisted from the mine through the 800-ft. shaft. The concentrating plant is equipped with jigs, tables, and oil flotation, and has a capacity of 2400 tons in 24 hr.

Utah.[1]—The mine output of recoverable zinc in 1920 was 8,157,739 lb., but market conditions prevented shipments of zinc ore or concentrate in 1921. The electrolytic plant of the Judge Mining and Smelting Co., at Park City, was closed in November, 1920, and zinc concentrates from the Judge mill were stored. Financial difficulties prevented the operation of the Utah Zinc Co.'s zinc-oxide plant near Murray, and at Midvale zinc concentrates from Bingham ore and old tailings were stored awaiting a better market.

Washington.[1]—Despite the low price of zinc in 1921, the Northwest mine, near Northport, continued to produce first-class carbonate ore, which was shipped East.

West Virginia.[1]—The extensions being made at the United Zinc Smelting Co.'s plant at Moundsville will give a total capacity of 22,000 tons of slab zinc and 40,000 tons of acid per year, or double the former output.

Wisconsin.[2]—Shipments of zinc ore from the Wisconsin zinc district in 1921, compared with those of 1920, are given in the accompanying table. The stock of blende concentrates in bins at the end of the year 1921 in terms of 60-per cent. zinc ore was 25,000 tons. Twelve concentrators operated during 1921, but of this number only one, the North Unity, operated steadily throughout the year.

Carbonate deposits of the Wisconsin district are apparently exhausted.

[1] U. S. Geol. Surv.
[2] J. E. Kennedy, *Eng. Min. Jour.*, Feb. 25, 1922.

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WISCONSIN ZINC-ORE SHIPMENTS
(Short Tons)

	Net to Smelteries, Tons.			Gross from Mines, Tons.		
	1919.	1920.	1921.	1919.	1920.	1921.
Highland	8,112	2,551	.....	8,112	2,551	.....
Linden	56	50	.....	865	1,869	.....
Mifflin	89	316	.....	20,874	29,405	12,174
Mineral Point	29,097	25,592	4,964	.....	.....	.....
Platteville	1,859	1,887	220	1,993	1,887	220
Dodgeville	.....	.....	.....	190	.....	.....
Cuba City	24,581	18,289	5,898	6,887	11,278	1,848
Benton-New Diggings	33,439	14,372	.....	82,516	50,501	2,269
Hazel Green	80	.....	.....	9,836	4,467	146
Shullsburg	2,742	.....	.....	8,585	3,024	.....
Galena (Ill.)	80	.....	.....	24,873	17,966	8,324
Totals	100,135	63,057	11,082	164,731	122,948	24,891

Joplin-Miami District.[1]—The year 1921 was one of retrenchment in readjustment of the mining business to accommodate new conditions. The feature of the year in the Joplin zinc-lead mining district was the admirable manner in which a complete rearrangement was effected. Losses were discharged to that account, and the meager profits, where made, were accepted as a gift. Mines, one after another, were closed down, until only those with the richest ore deposits could afford to operate, and even these would have failed to produce a profit with any class of labor other than the wholly American element employed in this district. Men accepted, one after another, the necessary wage reductions and even gave more of themselves in order to keep in operation the few mines able to withstand the shock.

The output of Oklahoma was all from Ottawa County and of Kansas from Cherokee County. Of the total Missouri shipment all but 1,214,780 lb. of blende and 120,860 lb. of calamine was produced in Jasper County, the tonnage excepted being the contribution from Newton County. No other county in southwest Missouri made ore shipments through purchasing agents in this district.

Newton County, with over 8000 tons of calamine shipped in 1920, found a market for only 60 tons last year. Greene, Ozark and Barry counties gave out some mineral wealth in 1920, but none in 1921. Arkansas, with little in 1920, reported less in 1921.

Readjustment lost to the Joplin district, according to 1921 valuation standards, almost $25,000,000. The decrease was 245,000 tons of blende, 10,075 tons of calamine, and 23,581 tons of lead. According to pre-war standards, the 1921 valuation is almost $2,000,000 below that of 1914 and more than $4,000,000 under that of 1913, though the tonnage of both blende and lead in 1921 exceeded either of those years.

[1] Jesse A. Zook, *Eng. Min. Jour.*

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The average weekly shipment of blende in 1921 was 6118 tons. Stocks in bins at the mines increased during the year 12,000 tons, or 231 per week, indicating an average production of 6349 tons per week. Demand for lead ore, in disproportion to its occurrence with zinc ore, occasioned the increased stock of blende. Operations at a number of mines were primarily for lead. Association of the two ores accounted for the blende production in excess of the demand.

SHIPMENTS OF ZINC BLENDE AND CALAMINE IN THE JOPLIN DISTRICT

	1920.		1921.	
	Blende, Pounds.	Calamine, Pounds.	Blende, Pounds.	Calamine, Pounds.
Oklahoma—Ottawa County	792,688,810	.....	467,630,340	.....
Kansas—Cherokee County	254,126,970	.....	131,103,170	.....
Missouri—Jasper County	76,523,580	1,790,750	37,686,370	.....
Newton County	2,369,680	16,481,540	1,214,780	120,860
Lawrence County	1,944,030	1,146,900	.....	.....
Other counties (a)	451,720	243,110	.....	.....
Missouri totals	81,289,010	19,662,300	38,801,150	120,860
District totals	1,128,104,790	19,662,300	637,534,660	120,860

(a) Includes ores bought by Joplin purchasing agencies in Greene, Barry, Ozark, Wright and Howe counties. Two cars each of blende and calamine from Arkansas are not included.

MONTHLY AVERAGE PRICES OF BLENDE AND CALAMINE IN THE JOPLIN DISTRICT
(Per Ton of 2000 Lb.)

	Blende.			Calamine.			All Zinc Ores.		
	1919.	1920.	1921.	1919.	1920.	1921.	1919.	1920.	1921.
January	$43.25	$53.90	$31.46	$35.28	$31.02	.....	$43.08	$53.35	.....
February	41.02	51.82	25.86	32.28	36.00	.....	41.03	50.69	.....
March	41.82	52.15	22.89	31.04	36.75	$16.00	41.70	51.27	$22.86
April	38.85	51.22	22.90	26.26	38.20	10.00	38.37	51.11	22.89
May	36.44	46.45	23.88	23.03	37.98	15.10	36.10	46.34	23.41
June	39.79	47.04	23.78	24.47	37.17	.....	439.69	46.90	.....
July	47.39	43.47	21.96	28.88	35.59	.....	46.75	43.33	.....
August	48.73	45.99	21.67	30.73	38.35	.....	48.30	45.64	.....
September	44.75	46.55	22.56	28.63	37.42	.....	4.06	45.12	.....
October	44.33	44.89	22.74	33.44	36.93	.....	43.78	44.53	.....
November	45.94	44.66	24.35	33.31	38.13	.....	45.77	44.52	.....
December	48.55	36.95	25.96	35.63	35.41	.....	48.35	35.00	.....
Year	$43.40	$47.01	$24.49	$30.24	$36 11	$14.03	$43.08	$46.49	$23.77

ORE PRICES IN THE JOPLIN DISTRICT
(Per Short Ton)

Year.	Zinc Ore.	
	High.	Average.
1907	$53.50	$43.68
1908	47.00	34.36
1909	55.00	41.08
1910	52.00	40.42
1911	51.00	39.90
1912	67.00	53.33
1913	59.00	42.26
1914	54.00	40.46
1915	138.90	79.30
1916	131.70	84.72
1917	101.95	67.70
1918	78.70	51.33
1919	57.60	43.08
1920	61.50	46.49
1921	36.85	24.49

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The blende in demand for the manufacture of prime-western grades of slab zinc began the year on a basis of $29 per ton of 60-per cent. zinc, declining the first week to $27.50 and in the fourth week to $22.50. This level held, with the exception of $21 the first week of March, until in the third week of April it was advanced to $25 for four weeks. In mid-May it dropped back to $22.50 and to $21 on the first and $20 at the end of June, holding this level to the last week in August, when for two weeks a considerable tonnage was purchased on a $19 basis. The end of September reinstated the price-level to $21. In October it was $22.50, $25, and $23. Throughout November a $25 basis prevailed, at which figure 30,000 tons of reserve stock was sold to avoid an Oklahoma taxation of $2 to $3 per ton. December opened with $26 and closed with $29 basis, re-establishing the opening quotation of the year. Grades of blende used in the manufacture of sheet zinc sold during a large part of 1921 on a like basis with prime western, on account of the

ZINC-SMELTING PLANTS OF THE UNITED STATES, END OF 1921 (a)

Company.	Situation.	Roasting Capacity. (b)	Number of Retorts.	Distillation Capacity. (c)
Plants using coal as fuel:				
American Steel & Wire Co.	Donora, Pa.	87,600	9,120	87,60
American Zinc Co. of Illinois	Hillsboro, Ill.	54,000	4,864	45,000
American Zinc & Chemical Co.	Langeloth, Pa.	62,000	7,296	73,000
Am. Zinc, Lead & Smelting Co.	E. St. Louis, Ill.	36,000	5,600	51,000
Eagle-Picher Lead Co.	Hillsboro, Ill.	16,000	3,200	24,000
Grasselli Chemical Co.	Terre Haute, Ind.	(d)	4,200	36,500
Grasselli Chemical Co.	Meadowbrook, W. Va.	(d)	8,400	73,000
Hegeler Zinc Co.	Danville, Ill.	36,000	5,400	30,000
Illinois Zinc Co.	Peru, Ill.	44,000	5,500	42,000
Matthiessen & Hegeler Zinc Co.	LaSalle, Ill.	44,000	6,132	44,000
Mineral Point Zinc Co.	Depue, Ill.	114,000	9,068	110,000
National Zinc Co.	Springfield, Ill.	36,000	4,480	45,000
New Jersey Zinc Co.	Palmerton, Pa.	.....	7,200	110,000
United Zinc Smelting Corp.	Moundville, W. Va.	32,000	2,368	27,000
Plants using natural gas:				0
Arkansas Zinc & Smelting Co.	Van Buren, Ark.	27,400	3,200	26,500
Athletic Mining & Smelting Co.	Fort Smith, Ark.	25,000	2,496	24,000
Bartlesville Zinc Co.	Bartlesville, Okla.	46,000	5,184	60,000
Bartlesville Zinc Co.	Blackwell, Okla.	73,000	4,800	43,200
Do., Lanyon-Starr Branch	Bartlesville, Okla.	36,500	3,456	24,000
Eagle-Picher Zinc Co.	Henryetta, Okla.	60,000	4,000	17,500
Edgar Zinc Co.	Cherryvale, Kan.	47,000	5,040	46,000
Fort Smith Spelter Co.	Fort Smith, Ark.	21,900	2,560	19,710
Grasselli Chemical Co.	Clarksburg, W. Va.	(d)	5,760	51,100
National Zinc Co.	Bartlesville, Okla.	36,000	4,256	45,000
Quinton Spelter Co.	Quinton, Okla.	16,425	2,016	16,000
Tulsa Fuel & Mfg. Co.	Collinsville, Okla.	19,000	6,232	75,000
U. S. Zinc Co.	Henryetta, Okla.	22,500	3,200	30,660
U. S. Zinc Co.	Kusa, Okla.	45,000	3,880	37,400
U. S. Zinc Co.	Sand Springs, Okla.	45,000	4,800	46,320
Weir Smelting Co.	Caney, Kan.	10,000	1,920	16,000
Totals	.....	1,092,327	145,628	1,439,290

(a) Am. Bur. of Metal Statistics.
(b) Estimated annual capacity, short tons of raw blende.
(c) Estimated annual capacity, short tons of roasted ore and calamine.
(d) The ore for these works is roasted in other plants of the Grasselli Chemical Co.
NOTE.—Outside of one or two small plants of more or less experimental nature, the Anaconda plant at Great Falls, Mont., was the only producer of electrolytic zinc in 1921 in the United States. Its capacity is about 66,000 short tons of slab zinc per annum.

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ZINC SMELTING WORKS IN FOREIGN COUNTRIES (a)

Company.	Situation.	Number of Retorts.	Ore Capacity. (c)	Zinc Capacity. (d)
Belgium:				
Soc. Métallurgique de Boom(e)	Boom	.....	.....	.....
Soc. Anon. G. Dumont et Frères	Sclaigneaux	4,800	55,000	22,000
Soc. Minière et Métallurgique de Peñarroya	Bleyberg	.....	18,000	7,000
Etablissements L. de Laminne	Ampsin	2,350	20,000	10,000
Soc. Anon. La Nouvelle Montagne	Engis-les-Liège	3,100	44,000	19,000
Soc. Anon. La Nouvelle Montagne	Cluysen(e)	.....	.....	.....
Soc. Anon. Métallurgique de Corphalie	Corphalie-les-Huy	4,380	50,000	20,000
Cie. des Metaux Overpelt-Lommel	Overpelt	2,832	43,500	18,000
Cie. des Metaux Overpelt-Lommel	Lommel	2,568	41,500	17,000
Soc. Anon. des Fonderies de Biache-St. Vaast	Ougrée	(b)	(b)	(b)
Soc. Anon. Métallurgique de Prayon	Prayon-les-Troos	3,840	65,000	26,000
Soc. Anon. de Rothem	Rothem	(b)	(b)	(b)
Soc. Anon. de la Vieille Montagne	Angleur	5,540	72,900	27,000
Soc. Anon. de la Vieille Montagne	Flône	4,896	50,000	20,000
Soc. Anon. de la Vieille Montagne	Valentin-Cocq (Hollogne-aux-Pierres)	10,800	122,000	42,000
Czecho-Slovakia:				
Weinmann-Werke	Schwats-Kuttowits A. T. E.	1,728	26,000	15,600
France:				
Cie. Métallurgique Franco Belge de Mortagne	Mortagne (Nord)	(b)	(b)	20,000(g)
Soc. Minière et Metallurgique de Peñarroya	Noyelles	(f)	(f)	(f)
Soc. Anon. de la Vieille Montagne	Vivies	4,752	56,000	23,000
Cie. Royale Asturienne des Mines	Auby	(b)	(b)	12,000(g)
Cie. Royale Asturienne des Mines	Rochefort	(b)	(b)	6,000(g)
Usine a Zinc de St. Amand	St. Amand-les-Eaux (Nord)	720	5,675	2,800
Germany:				
Rheinische-Nassauische Bergwerks- u. Hutten-Akt. Ges	Stolberg and Nievenheim	3,024	47,012	20,450
Akt. Ges. f. Bergbau, Blei- u. Zinkfabrikation su Stolberg und in Westfälen	Stolberg	(b)	(b)	32,000(g)
Metallwerke Unterweser Akt. Ges	Friedrich-August Hütte (Oldenberg)	2,076	28,000	13,000
Zinkhütten Hamburg	Hamburg-Billbrook	2,000	32,000	15,000
Akt. Ges. f. Zink Industrie vormals W. Grillo	Oberhausen	(b)	(b)	10,000(g)
Markish-Westfallischen Bergwerks Verein	.....	(b)	(b)	6,000(g)
Soc. Anon. de la Vieille Montagne	Borbeck	2,016	25,500	11,200
"Berzelius" Metallhütten Akt. Ges	Bensberg	1,764	27,000	12,000
"Berzelius" Metallhütten Akt Ges	Duisburg	2,592	27,500	13,500
Great Britain:				
Villiers Spelter Works (G. W. Winn)	Llansamlet, So. Wales	620	4,400	2,200
Williams, Foster & Co., and Pascoe Grenfell & Sons, Ltd	Swansea, So. Wales	1,500	15,000	6,000
Vivian & Sons, Ltd	Swansea, So. Wales	2,360	25,000	11,000
Brand's Pure Spelter Co., Ltd	Irvine, Ayrshire, Scotland	2,680	20,000	7,500
National Smelting Co., Ltd.(a)	Avonmouth	.....	.....	.....
Dillwyn & Co., Ltd	Llansamlet	(b)	(b)	(b)
Stewarts & Lloyds, Ltd	Halesowen	(b)	(b)	(b)
Down & Co., Ltd	Landore, So. Wales	(b)	(b)	(b)
Sulphide Corp., Ltd. (Central Zinc Works)	Seaton Carew	1,920	30,000	10,000
English Crown Spelter Co	Swansea	3,456	36,000	16,000
Swansea Vale Spelter Co., Ltd	Llansamlet	3,456	60,000	24,000
New Delaville Spelter Co., Ltd	Birmingham, Bloxwich, Warrington	(b)	(b)	6,000(g)
Holland:				
Soc. Anon. des Zincs de la Campine	Dorplein	6,432	80,000	30,000
Italy:				
Soc. di Monteponi	Vado Ligure	648	7,500	3,500
Japan:				

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ZINC SMELTING WORKS IN FOREIGN COUNTRIES (a) CONTINUED

Kuhara Mining Co.	Osaka	(b)	(b)	(b)
Susuki & Co.	Hikoshima	3,456	25,000	10,000
Mitsui Mining Co., Ltd.	Ohmuda-shi Fukuoka-Ken	3,456	32,000	12,000
Osaka Zinc Smelting Co.	Osaka	(b)	(b)	(b)
Jugo-Slavia:				
State Spelter Works	Cilli	(b)	(b)	(b)
Mexico:				
International Ore & Smelting Co.	Saltillo, Coah.	480	.....	.....
Norway:				
Glömfjord Smelteverk A/S	Glömfjord	(c)	(c)	(c)
A/S Ilens Smelteverk	Trondhjem	(b)	(b)	(b)
Jössingfjord Mfg. Co.	.....	(b)	(b)	(b)
Bremanger Kraftselskap Aktiebolaget	Sundloekken	.....	15,000	5,000
Norsk Elekstrisk Metalindustri A/S	Sundloekken	.....	17,500	6,200
Poland:				
Zinkhütten- u. Bergwerks Akt. Ges. vrom Dr. Lowitsch & Co.	Trzbinia	2,064	28,000	9,500
Soc. Miniere Franco-Russe	Dombrowa	(b)	(b)	(b)
Soc. des Charbonnages, Mines et Usines de Sosnowice	Sosnowice	(b)	(b)	(b)
Upper Silesia:				
Hohenlohe Werke, Akt. Ges.	Hohenlohehütte, O. S.	(b)	(b)	40,000(g)
Schlesische Akt. Ges. f. Bergbau- u. Zinkhüttenbetrieb	Beuthen, O. S.	(b)	(b)	36,000(g)
Die Grafen Henckel von Donnersmarck-Beuthen	Antonienhütte (2)	(b)	(b)	23,000(g)
Die Grafen Henckel von Donnersmarck-Beuthen	Radzionkau			
Bergwerksgesellschaft Georg von Giesche's Erben.	Schoppinitz (2), Rosdzin, Eichenau	(b)	(b)	42,000(g)
Furst von Donnersmarck'sche Bergwerks- u. Hüttendirektion	Schelsiengrube, O. S.	3,744	44,500	16,000(g)
Oberschlesische Zinkhütten	Bogutschutz-Süd	.....	.....	.....
Oberschlesische Zinkhütten	Friedenschütte bei Morgenroth, O. S.	3,356	40,000	15,000
Spain:				
Cie. Royale Asturienne	Arnao	(b)	(b)	(b)
Soc. Miniére et Métallurgique de Penarroya	Penarroya (Prov. de Cordoue)	.....	18,000	7,000
Sweden:				
Trollhättans Elektrothermiska Aktiebolag	Trollhättan	.....	20,000	7,000

(a) Am. Bur. of Metal Statistics. (b) Information not furnished. (c) Estimated annual capacity for ore smelting, in metric tons. (d) Estimated annual capacity for zinc production, in metric tons. (e) Under construction or reconstruction in 1921. (f) Idle; probably will not resume until 1923. (g) Estimated.

restriction of production of sheet zinc while the market was absorbing war stocks.

Following the period when the greatest record price ever attained for zinc calamine was reached, in 1920, the demand for this product entirely disappeared, except for a few transactions in mid-year on a $10 to $12 basis for 40 per cent. zinc, a price so low that all production was suspended.

Foreign Zinc Industry in 1921

Australia.—According to press cables received in Australia[1] there has been some discussion in the British House of Commons regarding the contract entered into between the British Board of Trade and the Zinc Producers' Association. In that discussion it was stated that the Board would take the earliest opportunity of terminating the contracts, but although several members desired explicit information as to the rates

[1] *Eng. Min. Jour.-Press*, Apr. 8, 1922.

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to be paid for concentrates, the Government refused to divulge the information.

The conditions attached to the contract, as published in *Chemical Engineering and Mining Review*, were as follows:

The contract was for the period of the war and ten years after, including the stocks on hand at the end of 1917, which were purchased at the flat price of 66s. per ton on the stacks at Broken Hill. The scale of future output was made over three periods: First, during the war and one year after; second, four years after that; third, five years after that.

1. During the war and one year after: 250,000 tons annually at the following prices: 100,000 tons at 90s. per ton, f.o.b. Port Pirie; 100,000 tons at 80s. per ton, f.o.b. Port Pirie, and half of any profit on resale; 50,000 tons at 80s. per ton, f.o.b. Port Pirie.

2. Four years after that: 300,000 tons annually at 90s. per ton, Port Pirie, and half the profit on resale, less 100,000 tons to be alloted to British smelters.

3. Five years after that as No. 2 period.

The assay basis for the whole period is: Zinc 47 per cent., lead 7 per cent., silver 10 oz. per ton; any variation at the rate of 4s. per unit zinc, 1s. 3d. per unit lead, and 1s. 3d. per oz. silver. No payment for silver if under 5 oz. per ton. Excess freight over 60s. to be halved, but the price to be not less than 80s. per ton in any case.

The journal above mentioned, in commenting on the position, states: "As a rough estimate of the value at these prices, it may be mentioned that on the basis of pre-war freights and smelting rates spelter would have to be about £28 per ton to warrant the price being given. With freights about 10s. per ton higher than pre-war and smelting rates on a higher basis, and spelter ranging about £25 per ton, it can be seen that the contract cannot be a favorable one to the British Government, and also that there is no likelihood of any surplus being divided with the producing companies."

The Electrolytic Zinc Co. of Australasia started its first unit of the main plant at Risdon, near Hobart, Tasmania, on Nov. 22, 1921, absorbing 15,000 hp. The complete plant, absorbing 30,000 hp., should be running well before the end of 1922, with an output of 40,000 to 45,000 tons of refined zinc per annum. Before the close of 1922 the company should be exporting annually 10,000 tons of zinc oxide, 15,000 tons of zinc-lead oxide, and from 10,000 to 15,000 tons of lithopone, with quantities of zinc sheets and lead bullion, in addition to the output of slab zinc.

What to do with the upward of 750,000 tons of zinc concentrates accumulated in Australia under the British Government contract, and of which, as shown above, the Government is trying to rid itself, is a problem for discussion seemingly without end. Forward contracts are cited as a possible solution, but the existing world zinc industry lends slight promise of an early solution from this source.

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From official reports the comparative situation in Australia is given in the following table:

	Long Tons. 1920.	1921.
Production of zinc in concentrates and ores	*Nil.*	139,460
Smelter production of spelter and zinc	9,665	1,681
Exports of zinc (as spelter and zinc)	5,689	1,403
Exports of zinc in concentrates and ores	24,242	19,616
Imports of zinc	.....	948
Home consumption	.....	4,984

The small distillation works at Port Pirie remain closed and are unlikely ever again to produce, considering the ability of the same interests to turn out high-grade zinc so much cheaper at the Risdon electrolytic works. The latter plant, with its cheap hydro-electric power and other natural advantages, can produce 99.95-per cent. zinc for £21 per ton when running at full capacity. The company has sold its entire output up to 45,000 tons per annum to the British Government until June, 1930, at a substantial premium over the London market price.[1]

The following table shows the total zinc output and exports since 1910, in long tons:

Year.	Production.	Exports.
1910	186,170	185,681
1911	203,054	201,054
1912	212,397	209,823
1913	232,472	228,202
1914	156,528	152,815
1915	73,482	71,007
1916	94,039	92,126
1917	49,982	46,022
1918	29,576	24,044
1919	27,152	22,446
1920	33,907	29,931
1921	.....	21,019

Belgium.—During 1921 Belgian imports of zinc ores ran close upon 190,000 long tons, of which around 75,000 tons was calamine and the balance blende. Of the latter, Australian concentrates probably accounted for about 47,000 tons. The Belgian production of spelter during 1921 amounted to 66,470 long tons, and it would appear that the imports had been pretty well used up.

There was, however, a fair stock of ore on hand at the commencement of 1921, and it must be assumed that a balance remains of 100,000 tons at least. Belgium, therefore, is probably in a position to increase output so far as supplies of raw material are concerned, and may be able to produce at a level much nearer the present market price than is often supposed.

American interests have made tentative inquiries as to the possibility of shipping Joplin zinc ore to Europe. This ore runs about 60 per cent., and is therefore very high grade. It is difficult to believe, however, that European smelters can pay a suitable price to enable business to result.

[1] *Eng. Min. Jour.-Press*, Apr. 15, 1922.

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Belgium's exports of spelter last year were 38,195 long tons, against 17,707 tons in 1920. Of the total France took 9335 tons (8194 tons in 1920), the United Kingdom 19,834 tons (7834 tons), Japan 3034 tons (157 tons), and Holland 2387 tons (546 tons).

Last year Belgium imported 189,096 tons of zinc ores, against 279,615 tons in 1920. The chief contributors were as follows: Algeria 21,859 tons (in 1920 23,307 tons), Australia 29,025 tons (5977 tons), Spain 14,066 tons (65,052 tons), China 18,164 tons (9662 tons), Italy 45,047 tons (37,859 tons), and Sweden 19,898 tons (61,513 tons).[1]

[1] *Metal Bull.*, Feb. 10, 1922.

YEARLY PRODUCTION OF ZINC IN BELGIUM

Year.	Number of Retorts.	Number of Workers.	Tons of Coal.	Ore Used, Metric Tons.	Zinc Produced, Metric Tons.
1913	43,453	8,529	998,655	488,730	204,220
1914	30,765	8,142	715,815	340,700	145,925
1915	10,448	4,397	262,020	124,890	51,660
1916	5,182	4,044	142,020	59,750	22,930
1917	1,898	1,586	81,080	27,100	10,290
1918	1,643	764	64,430	23,190	9,245
1919	9,040	3,714	117,850	52,590	19,860
1920	18,201	4,779	406,300	193,340	84,260
1921	.....	.....	.....	.....	67,540

Canada.[1]—Based on smelter recoveries, the production of zinc showed a remarkable increase in comparison with the record for 1920. The Canadian production in 1921 amounted to 53,095,600 lb., which at the average St. Louis price for the year of 4.655 cts. per lb. was worth in Canadian funds $2,758,552, as against 39,863,912 lb. valued at $3,335,-496, Canadian funds, in 1920. These data show an increase of 33.2 per cent. in quantity, but a decrease of 17.3 per cent. in value. Of the total Canadian production, the refined zinc produced by the Trail smelters amounted to 52,988,000 lb. and a total of 107,609 lb. was estimated as recovered from some 176 tons of ore and concentrates shipped to United States smelters (25 per cent. of the zinc contents being allowed for smelter losses). The production in 1920 included 37,034,000 lb. of refined zinc and 2,829,900 lb. estimated as recovered from exported ores. The total zinc ore and concentrates shipped from the mines in 1921 amounted to approximately 297,400 tons, having a metal content of about 78,920,300 lb. of zinc. These shipments also contained a large quantity of lead. As in other years, the production was derived entirely from British Columbia. Quebec, which formerly produced about a million pounds per year, did not report the shipment of a single consignment of zinc ore or concentrates, although ores containing lead were exported.

As a result of the decline in metal prices and the consequent closing down of nearly all the United States zinc smelters which formerly treated

[1] Prelim. Rept. Min. Prod. of Canada, 1921, Dominion Bur. of Statistics.

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considerable amounts of Canadian ore, many small operators in British Columbia were compelled to discontinue for a time.

CANADIAN ZINC STATISTICS (a)

	1917.	1918.	1919.	1920.	1921.
Ores and concentrates shipped, tons	116,489	121,200	135,535	249,136	297,400
Zinc production, tons	14,834	17,542	16,097	19,932	26,548
Refined zinc product, tons	9,985	12,574	12,326	18,517	26,494
Imports of zinc, tons	18,566	15,655	13,223	13,636	.....
Exports of zinc ore, tons	(b)5,972	10,545	6,630	3,126	52
Exports of metallic zinc, tons	(c)	(c)	3,847	3,490	641

(a) Annual Rept., Mines Branch, Can. Dept. of Mines; last year from Prelim. Rept. (b) Nine months only. (c) Previous to 1919 not separately classified.

Within the past few years the Consolidated Mining & Smelting Company of Canada has become a very substantial producer of spelter, its Sullivan mine ore carrying zinc values and the plant at Trail, B. C., having been brought to the point metallurgically that permits an economical reduction of the ore and the shipment of the spelter at a cost that gives assurance of at least a fair chance of successful competition in the open market. The electrolytic plant of the Trail smelter was installed during the war. It then was an experiment to a large extent. The result was a considerable output of zinc which was sold at prices below those obtaining elsewhere. Research work has been going on constantly which only recently has had its reward in bringing methods of treatment, particularly with regard to the ores of the Sullivan mine, to that stage of perfection beyond which it can scarcely be expected to go. An additional plant is to be provided for the handling of custom zinc-bearing ore of the Kootenays. The benefits, therefore, are to accrue not to the company alone but to many of the independent operators of eastern British Columbia.[1]

France.—The spelter works in the North of France during 1921 were working on a basis of about 20,000 tons annually. This figure is scarcely half the pre-war output, as the works produced in 1913 about two-thirds of the total French production of 70,000 tons. The output of the various concerns in 1913 was as follows: Auby, 24,000 tons; Mortagne, 20,000 tons; Noyelles-Godault, 8000 tons; and St. Amand, 3000 tons. The zinc smelters at Auby, which belong to the Cie. Royale Asturienne des Mines, were operating at half their pre-war capacity. These works have 33 furnaces (over 6000 graphite crucibles), and 12 rolling-mills. Mortagne du Nord and St. Amand-les-Eaux, both situated near the Belgian frontier, belong to the Cie Metallurgique Franco-Belge de Mortagne. At Mortagne four furnaces were operating in September and the remainder were ready for operation at the end of the year.

[1] *Can. Min. Jour.*, Apr. 14, 1922.

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The St. Amand works have had three furnaces working since 1920. The Noyelles-Godault works in Artois are owned by the Peñarroya Co., which acquired them from the Soc. de Malfidano. No resumption of zinc smelting here is contemplated before 1923.[1]

La Compagnie Française du Zinc will soon put into permanent operation its new works at Berre (Bouches-du-Rhône), near Marseilles. The plant has a yearly capacity of 6000 tons of zinc white, 6000 tons of lithopone, 3000 tons of agricultural lime, and 6000 tons of ground or precipitated baryta. The concern owns two subsidiaries, La Soc. Française des Produits Chimiques et des Blancs de Comines, with works at Comines, and La Magnésie Française with plants at Berre.[2] It is a question whether the northern France smelters in a more or less distant future be able to compete with the Pyrenean electrolytic works now in course of erection, *viz.*, the Pierrefite plants belonging to the Société Minière & Metallurgique de Peñarroya, and the Aveyron plants which the Vieille Montagne now is electrifying.

These works will find ore on the spot, and will use the hydro-electric energy supplied by the numerous waterfalls (of late the Peñarroya company has completed the installation of its St. Lary electric works in the Hautes-Pyrénées). One consideration, however, will continue to favor the smelting works of northern France and that is that the bulk of the zinc produced is consumed in the galvanizing industry, largely represented in the Norde in the Valenciennes and the Escaut areas.[3]

Germany.—According to a review of the zinc market in 1921 published in the German technical press, the market was quiet throughout the year and presented few features of interest. The prevailing conditions were not such as to encourage production, prices being unremunerative, stocks heavy, and the demand poor. The total production for the year showed, therefore, a considerable falling-off, in spite of the inducement which was to be expected from the depreciation of the Continental exchanges. At the beginning of the year the market was largely influenced by German sales, but in the last months these were relatively unimportant, most of the available metal being taken by the Continent, the increased demand from which was a feature of the close of the year. Consumption was throughout very restricted, and there was practically no speculative buying. The only purchases of importance were effected in September and October, following a good flow of exports of galvanized sheets to India, galvanized-sheet manufacturers having bought largely and strengthened prices. Otherwise, consumers were inclined to buy from hand-to-mouth, and their orders were keenly competed for. The

[1] *Metal Bull.*, Sept. 23, 1921.
[2] *Metal Bull.*, Mar. 17, 1922.
[3] *Min. Jour.*, Sept. 3, 1921.

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demand for zinc for brass manufacture was very weak, owing to the existence of large war stocks of brass. Towards the end of the year consumption showed some improvement; Belgium sold a large part of her surplus production to France, in the form of zinc sheets for building purposes; in Germany, the industrial boom was no doubt responsible for the absorption of a large portion of the home production.[1]

At the close of the year the production of zinc at the German works and at the smelters in Silesia now within Polish territory was not more than the present consuming capacity of the country. The outlook at the Silesian works is still unsatisfactory, and production at that center is on a small scale compared with the rated capacity.

India.—In an illuminating report of the property of the Burma Corporation, E. P. Mathewson as consulting engineer stated that . . . the mill was built with a view to the production of zinc concentrate suitable for retorting and lead and silver concentrate suitable for smelting. Results have never equaled the expectations of the builders so far as the zinc concentrate is concerned. In fact, the taking out of a zinc concentrate has been discontinued. . . . It is fallacious to consider the zinc in the ore as an asset under existing conditions.

Italy.—The Italian production of zinc ore in 1921 was 69,000 metric tons, against 73,180 tons in 1920, and that of spelter amounted to 380 tons, against 1172 tons in 1920.

Japan.—Mining of zinc ore and the manufacture of slab zinc has practically ceased in Japan, a possibility indicated a year ago. Information on that country's position with regard to zinc is conveyed in the statistics of exports of slab zinc from the United States. Of total exports in 1921 amounting to 4,785,653 lb., the amount sent to Japan was 2,645,355 lb., or 55 per cent. In 1920 the exports to Japan were 4,738,527 lb. out of a total of 204,354,308 lb., or only 2.3 per cent.

The following table shows how the production of zinc ore steadily declined, but that the output of refined zinc increased until 1918:

Years.	Zinc Ore.		Refined Zinc.	
	Metric Tons.	Value.	Pounds.	Value.
1913	34,676	$472,303	(a)	(a)
1914	14,138	140,752	13,140,265	$682,454
1915	6,121	179,845	46,958,601	6,456,866
1916	2,187	91,257	86,652,236	13,567,052
1917	163	13,576	121,596,436	13,462,153
1918	(a)	(a)	88,701,073	8,838,867
1919	(a)	(a)	43,674,000	.....
1920	(a)	(a)	34,712,000	.....
1921	(a)	(a)	26,456,000	.....

(a) Production not stated.
[1] *Min. Jour.*, Jan. 28, 1922.

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Poland.[1]—The Silesian frontier between Germany and Poland has now been decided. The whole of the spelter works are on the Polish side, while of the zinc mines only 15 per cent. remain on German soil. The whole of the Schlesische Zinkhütten properties are now Polish, with the exception of the Karsten-Zentrum mine. It is thought that Poland will receive the benefit of the whole of the ore output, leaving the great West-German smelters and German zinc-working plants to seek other sources of supply, mainly Australia.

Out of sixteen zinc and lead mines in Upper Silesia, only four are to be retained by Germany, *viz.*, a part of the State-owned Friedrichsgrube, and three privately owned mines, with a yearly production of about 39,000 tons of zinc ore, and about 5000 tons of lead ore. These figures compare with 266,000 tons of zinc ore, and 22,000 tons of lead ore produced by the whole industry of the province.

British capital has already become interested in Poland's zinc industry a private company having been registered under the style Henckel von Donnersmarck-Beuthen Estates, Ltd.

It is becoming clear that the cession of a great portion of the Upper Silesian industries to Poland will not entail the substitution of Polish capital, in place of German, in the works. The chief share in the industries will probably be acquired by French interests, who are preparing to take over the State mines, and it is understood that Czech capitalists may co-operate with the French. There is an expectation of complications occurring through the fact that the staffs of French-controlled works will be paid in French currency, which, of course, stands at a high rate of exchange compared with the Polish mark. There is a section of Czech industrialists willing to put money into the works which remain German, notably the Hohenlohewerke and the Königs and Laurahütte.

Scandinavia.—The output of zinc in Norway and Sweden is today little more than the requirements of Scandinavian consumers. The electrothermic process has been developed to such a state of perfection that it is placed next to the electrolytic process in economy of production, compared with the ordinary distillation methods which have to be employed where cheap hydro-electric power is unobtainable.

The zinc smelting works at Glömfjord, Norway, are experiencing difficulties, owing to the lack of demand for zinc. The company is undertaking to raise further capital and assistance may be sought in Great Britain or in Belgium. At present the control is in the hands of Swedish interests. The power installation at Glömfjord is owned by the Norwegian Government, which has invested large sums in it.[2]

Zinc exports from Norway in 1921 amounted to 17,207 metric tons,

[1] *Metal Bull.*, Oct. 28, Nov. 3, Dec. 9, 1921.

[2] *Metal Bull.*, Aug. 9, 1921.

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a considerable improvement over the exports of 11,187 tons in 1920. Imports were 7069 tons in 1921 compared with 14,986 tons in 1920.

Zinc exports from Sweden in 1921 also increased—4275 metric tons compared with 1411 tons in 1920. Imports were 866 tons against 3154 tons in 1920.

Spain.—In Spain, 69 zinc-ore mines were operating in 1919, two less than in 1918. The total production was 103,608 metric tons. The amount of zinc ore mined has steadily declined since 1916, when it was above the pre-war average of about 152,000 tons. One-third of the zinc was mined in the Province of Santander in 1919, whereas in 1918 the Province of Murcia led, the zinc in this province being derived from the blended lead and zinc ores of the Cartagena district. Only two refineries operated in 1919, in Cordoba and Oviedo, with an output of 11,583 tons of crude zinc, 4260 of sheet zinc, and 462 tons of refined zinc.[1]

United Kingdom.—The outlook is improving for British spelter works. Three obstacles have stood in the way of their reopening: the cost of coal, the cost of labor, and the cost of concentrates. The coal problem is settling itself. As regards wages, the Spelter Manufacturers' Association has decided to offer the men 50 per cent. above the pre-war rate, together with a bonus on output, and if the men accept this offer the manufacturers will have a strong card to play with the Board of Trade in connection with the supply of concentrates at a practicable price. One works—Swansea Vale—has several thousand tons of concentrates in stock, and if negotiations proceed in the right direction would be in a position to make an early start.[2]

Villiers' Spelter works, near Swansea, restarted 50 per cent. of its plant Oct. 4. This is the first Welsh spelter works to reopen after many months of idleness.

Arrivals of Australian zinc concentrates began in South Wales early in 1922. Probably about 8000 tons a month or so can be used by smelters in Great Britain. As British consumers are at present, however, using about 11,000 tons of zinc a month, it is obvious that considerable quantities will still have to be imported.

After negotiations between the Board of Trade and the representatives of the British smelters, the former agreed to make 40,000 tons of Australian zinc concentrates available to the British works at a price of 75s. per ton c.i.f. As the grade of the Broken Hill material is 47 per cent. zinc, 6 per cent. lead, and 10 oz. of silver per ton, the price mentioned is equivalent to a government subsidy to the British zinc industry and is more than 20s. per ton below the market value of other zinc ores in Europe. As the ocean-freight for cargoes has ranged between 45s. and 51s. 3d. per

[1] *Suppl. to Comm. Rept.*, 1921.

[2] *Metal Bull.*, Oct. 7, 1921.

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ton, it follows that the Board of Trade has incurred a heavy loss in agreeing to supply the 40,000 tons at the price mentioned.

The Board of Trade is only prepared to deal on an f.o.b. Port Pirie (Australia) basis, and as existing ocean-freights are double the pre-war rates, the price concession is at least counterbalanced from the smelters' viewpoint. The first of such long-term contracts has already been signed, and notwithstanding the high freight, Broken Hill material imported under this contract is easily the cheapest source of zinc ore supply.

Several of the British smelters are running at part capacity, the aggregate output hardly exceeding 2000 tons per month. This will expand, however, and probably the large plant at Avonmouth will be brought into operation before the end of 1922.[1]

United Kingdom imports of slab zinc in 1921 amounted to 72,486 long tons, compared with 109,367 tons in 1920, 94,226 tons in 1919, and 61,138 tons in 1918. Imports of zinc sheets in 1921 were 11,031 long tons, against 7524 tons in 1920, 4697 tons in 1919, and 3023 tons in 1918. Zinc exports in 1921 were 7424 long tons, compared with 10,177 tons in 1920.

WORLD'S PRODUCTION OF ZINC (*a*)
(Smelter output, in metric tons)

Country.	1915.	1916.	1917.	1918.	1919.	1920.	1921.
Australia (*c*)	5,393	5,362	4,769	5,712	3,625	3,909	*Nil.*
Austria (*g*)	(*b*)	(*b*)	(*b*)	(*b*)	(*e*)4,000	(*e*)6,000	(*e*)6,000
Belgium	51,660	22,930	10,290	9,245	19,860	84,260	66,457
Canada	20	2,698	9,058	11,139	11,182	16,798	24,035
China (*d*)	2,329	775	432	129	109	98	.....
France	19,180	20,258	22,929	18,347	10,800	19,655	(*h*)30,000
Germany (*f*)	195,000	196,000	181,000	236,000	(*e*)148,000	95,758	(*h*)90,000
Great Britain (*f*)	45,000	60,000	50,000	50,000	35,000	24,500	5,910
Holland	11,130	12,102	4,062	680	.....	2,031	6,405
Italy	.....	258	367	1,188	1,282	1,172	380
Japan	21,132	38,994	(*f*)54,606	(*f*)39,834	(*h*)19,816	(*h*)15,745	(*h*)12,000
Norway	25,000	32,000	22,000	1,855	(*e*)3,400	1,836	(*h*)2,000
Russia (Poland)	2,000	1,100	(*b*)	4,893	(*h*)4,416	(*h*)5,361	(*h*)7,026
Siberia	.....	213	569	(*b*)	(*b*)	.....	.....
Spain	8,117	8,523	10,155	15,900	16,310	(*h*)5,869	(*h*)6,000
Sweden	8,588	9,997	7,979	4,098	2,319	1,450	(*h*)3,500
Tasmania	.....	.....	49	3,883	3,727	5,911	1,708
United States	444,082	606,307	607,423	469,853	422,520	420,366	181,894
Total	838,631	1,017,517	985,688	875,156	706,366	710,719	443,315

(*a*) From official reports of the various countries, except as noted. (*b*) Statistics not available. (*c*) Except Tasmania. (*d*) Exports. (*e*) Estimated. (*f*) Imperial Mineral Resources Bureau, London. (*g*) After 1918, Jugo-Slavia and Czecho-Slovakia. (*h*) Am. Bur. of Metal Statistics.

[1] *Eng. Min. Jour.-Press*, Apr. 15, 1922.

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METALLURGY OF ZINC[1]

BY W. R. INGALLS

GENERAL INDUSTRIAL CONDITIONS

Mining.—During 1921 the Oklahoma mines dominated the American zinc-producing industry. They comprised the only group that could produce under the adverse conditions that prevailed. At the beginning of 1921 there were about 34 mills in operation in the Tri-State district, out of a total estimated variously at 150 to 200, and these were producing at the rate of about 5000 tons of blende concentrate per week. At the end of 1921 there were about 50 mills in operation. The Tri-State district rates about 80 men to the mine and mill on the average, which will give an idea as to the extent of the employment of labor in this district.

Smelting.—The zinc smelters in 1921 experienced a disastrous year. All of them operated at greatly reduced capacity and probably most of them suffered loss in operations. Smelting costs came down to a considerable extent by virtue of drops in the price for coal, wage reductions and more efficient work, but these ameliorations were insufficient to enable the smelters to come out even. In the Illinois fields wages at the end of 1921 had been reduced about 37 per cent. from the peak (middle of 1920), but coal continued to be very dear. The operation of works at a very low rate of their capacity was a discouraging and expensive condition.

At the end of 1921 the zinc-smelting capacity of the United States was as follows:

Class of Plant.	Roasting Furnaces.	Distillation Furnaces.	
	Annual Capacity, Tons of Raw Blende.	Number of Retorts.	Annual Capacity, Tons of Roasted Ore and Calamine.
Coal-fired	561,600	82,828	804,100
Natural-gas	530,725	62,800	641,190
Total	1,092,325	145,628	1,445,290

For comparative purposes the above figures need some correction, inasmuch as certain smelters have no roasting furnaces at their works but treat ore roasted in other works. If allowance be made for such extraneous roasting capacity, the total for the country will appear to be about 1,300,000 short tons, corresponding to about 1,100,000 tons of calcined

[1] *Min. & Met.*, July, 1922.

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ore, and leaving about 340,000 tons of distilling capacity to be supplied with calamine.

I estimate the above capacity as being sufficient for the production of 625,000 tons of spelter per annum, besides which at least 9000 tons additional can be derived from the smelting of galvanizers' dross along with the ore. Anaconda's capacity for producing electrolytic zinc is about 66,000 tons per annum. Consequently the total zinc-producing capacity of the United States was about 700,000 tons (in terms of spelter). This is roughly twice the maximum pre-war rate of consumption.

Direct Oxide Manufacture.—The production of zinc oxide directly from the ore was affected adversely by the industrial depression, just as was the spelter business, but perhaps not to the same extent. Up to the middle of 1921 the price for zinc oxide was 8¾ cts. per lb. A reduction then was made to 7¾ cts. per lb. in barrels and 7½ cts. in bags. Zinc oxide is now largely shipped in bags, which is more economical to the producer than is shipment in barrels. The differential of ¼ ct. per lb. allows only 75 cts. for the 300-lb. barrel, while at the present time the actual cost of barrels for this purpose is something like twice that figure.

Metallurgy

In reviewing the progress in the metallurgy of zinc it is ever difficult, if not impossible, to emphasize any particular thing as being an event of the year. Developments are always gradual. Our record of them usually reflects only the time when they begin to attract general attention.

Roasting.—One of the greatest rooms for improvement in the metallurgy of zinc is in blende roasting. We do not possess any really good mechanical furnace for the desulphurization of blende when use of the sulphur gases for acid-making is also necessary. The Hegeler furnace does the work and American smelters employ it with only few exceptions, but after all it is only a semi-mechanical furnace.

During 1921 a trial was made at Cuba City, Wis., with a new design of the Wedge furnace. It came to an untimely and inconclusive end owing to failure of the stirring arms at the temperature to which they were subjected. Nevertheless, the indications from this run were encouraging.

The Central Zinc Co. at its smeltery at Seaton-Carew in England adopted a full-sized unit of the Rigg blast-roasting system, with which, working on a small scale, extraordinarily good results were obtained in desulphurizing Broken Hill concentrates, the total sulphur being reduced to under 0.75 per cent. and the product being a sinter as porous as pumice which yields its zinc in distillation at a lower temperature and with much greater ease than does ordinary well-roasted concentrate.

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There was litigation during 1921 between the American Zinc, Lead & Smelting Co. and the New Jersey Zinc Co., the latter alleging infringements of the Tucker patent for improvements in the mechanism in connection with the Hegeler roasting furnace. Late in the year Judge Hale of the Federal Court at Portland, Me., held that the patent was invalid, on the ground that it was a combination of old elements and old results with no new function.

Distillation.—Our distillation practice also has room for improvement. Among the directions to which attention may usefully be given are the matters of reducing the quantity of between-products to be resmelted and the introduction of the charge in briquetted form, which may accomplish surprising things in the ways of increasing the speed of the reactions, their degree, furnace capacity, etc.

The benefit in distillation that may result from a blast-roasted sintered product has been previously referred to, and has been well established by the results at Port Pirie and Seaton-Carew. Coked charges and briquetted charges are further steps in the same direction.

Julius W. Hegeler did some interesting work at Danville, Ill., on the preparation of a charge for distillation by mixing coal and calcined ore and coking the mixture, producing a "zinc coke" which is loaded with all of the ore that it will carry. Using the local coal it was found possible to prepare a product consisting of 34 parts coke and 100 parts calcined ore, this product being remarkably firm. In the retorts this behaves very well, and the accomplishment of the close contact of the ore and carbon in the coked charge is found to be very well worth while.

Naturally we had no new furnace building in 1921, but rather was there more or less tearing down. The United States Zinc Co. began the dismantling of its distilling furnaces at Blende, Colo., and that plant will never be started again as a spelter-producing plant unless the type of furnace is entirely changed. This plant was built originally by engineers from Overpelt, Belgium, and was equipped with the Overpelt type of Rhenish furnace. Furnaces of the Rhenish type have been tried experimentally in other American works, but Blende has been the only plant wherein their use was the regular practice. In spite of alterations in the form of furnace front and otherwise, the metallurgical results were never satisfactory.

Blue Powder.—I had occasion during 1921 to look into the subject of blue-powder production. I reported the results of this in a paper in *Mining and Metallurgy* for April, 1922.[1]

Although every zinc smelter is aware that more or less blue-powder production is inevitable and there is a common practice as regards the

[1] The discussion here given is abstracted from that paper.

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treatment of it, the specific and quantitative data respecting the subject were more imperfect than would have been expected. I had reports from eight important works.

Speaking generally, there is a good deal of uniformity in the figures, all of which show that the blue-powder product bears a large proportion to the ore originally charged into the retorts; that a large proportion of the retort capacity is devoted to the redistillation of blue powder; and that of the spelter product of a furnace about 30 per cent. is derived from blue powder, *i.e.*, it is zinc that has been distilled twice. The figures from the works are given in the following table:

	Per Cent. Retort Capacity Devoted to Blue Powder.	Per Cent. Spelter Made from Blue Powder	Per Cent. Blue Powder to Ore.	Assay of Blue Powder, Per Cent. Zn.
A	22¼	32	..	....
B	....	....	35	51
C	23¾	30	..	....
D	....	30	..	62½
E	....	24½	..	....
F	....	33½	50	....

In American zinc-smelting terminology, blue powder is different from what it is in the European. In Europe blue powder is finely divided metallic zinc, more or less oxidized, which is collected in the prolongs. This is blue powder, strictly speaking. It is formed in relatively small quantity and is of relatively high grade in zinc.

In America it is the ordinary practice to throw in one pile the blue powder coming from the ladle-skimmings, together with the retort-samplings, condenser-scrapings, condenser chips, and floor-sweepings. This produces a large weight of material of low grade in zinc on the average.

One smelter reported that for a high-grade roasted ore containing about 70 per cent. zinc the following would be close to representative results:

Ladle-skimmings, 19 per cent. of weight of ore, contents 80 per cent. zinc.
Retort-samples, 9 per cent. of weight of ore, contents 35 per cent. zinc.
Condenser chips, 3 per cent. of weight of ore, contents 45 per cent. zinc.
Total by-products, 31 per cent. of weight of ore, contents 27 per cent. zinc.

The above figures represent the by-products from the ore plus the by-products from re-treating the original by-products. This is the condition as it exists from day to day in the operation.

With very low-grade complex ores, the zinc contents of the by-products is often as high as 45 per cent. of the contents of the original ore. This means that the metal recovered directly from ore to spelter is very low on these ores.

Improvements in methods for the minimizing of the quantity of these by-products and for the re-treatment of those that will be made inevitably is obviously a subject that deserves very careful consideration.

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At the present time an amount of material approximately equivalent to one-third of the ore originally charged must be rehandled and re-treated, not only at direct expense, but also at the cost of the use of a corresponding amount of furnace capacity. Furthermore, about 30 per cent. of the zinc in the original ore is subjected to loss in distillation a second time, which loss in terms of percentage is undoubtedly as large as the loss in the first distillation.

In European zinc-smelting practice the quantities and assays of the blue powder and other by-products are decidedly different from the American. In one plant, excellently managed, which commonly works on a roasted blende containing 49 per cent. Zn, from which an extraction of 85 to 86 per cent. in the form of spelter is made, typical figures are the following:

	Per Cent. of Ore Charged.	Assay in Zinc, Per Cent.
Sweeps from drawing	5.24	56
Condenser chips, etc	3.77	60
Blue powder	3.96	83
Total	22.97	

Computation of the above figures shows that 100 lb. of ore yields about 23 lb. of by-products containing about 14 lb. of zinc. Inasmuch as 100 lb. of ore yields finally about 42 lb. of zinc the quantity that goes first into the by-products is about one-third of what ultimately is produced as spelter. This is not very different from American figures, but the quantity of the by-products is less than we make, on the whole. Moreover, it is to be considered that the grade of the ore distilled in this works is lower than what we treat. It is well known that the percentage of by-products decreases as the ore increases in grade. Thus, in treating ore of 51-per cent. grade in the same works, ladle-sweeps fell to 10.33 per cent., condenser chips to 2.73 per cent. and blue powder to 2.74, a total of 15.8 per cent.

In these works the sweeps is what is obtained from the condenser and ladle in drawing. The old condensers are not only chipped, but after chipping they are crushed and concentrated over Wilfley tables. The blue powder is what is obtained from the prolongs. American zinc smelters do not use prolongs. Consequently the blue powder obtained from them and also the condenser concentrates are over and above what we get in American practice.

Electrolytic Extraction.—The art of electrolytic zinc extraction made great headway during 1921, especially in the direction of improving the yield of zinc. At Great Falls the extraction did not use to be very good, although there was always a confidence that material improvement would be effected. This has been accomplished by a careful control of the

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roasting operation, wherein the temperature is kept at about 650° C., which prevents the formation of zinc ferrite to any great extent. If that be avoided the percentage of zinc solubility may be expected to rise, and in fact that is the case, with the results that zinc extraction at Great Falls has become pretty high even in treatment of low-grade ore. With high-grade ore (45 to 50 per cent. zinc) it may be very high.

I have always been of the opinion that the electrolytic process is best with a relatively high-grade ore, and I believe that all experience is confirmatory of that opinion. At Trail the ore heretofore treated has been of relatively low grade in zinc and extractions there also have been rather poor, but the selective process of flotation has now been introduced for the preliminary treatment of the ore and this is giving a higher grade of blende concentrate, with which the electrolytic plant is giving better results in the matter of zinc extraction.

The electrolytic process has experienced a good many improvements in details. The washing of the filter cakes is better done, with reduced loss of soluble zinc. Greater regularity in current efficiency is being obtained. Mechanical details are being improved. As I reported last year, the difficulties arising from impurities have been thoroughly mastered. It is no longer necessary to supply sulphuric acid to the process, but rather is it a question of getting rid of a surplus. If an electrolytic zinc plant be situated in a region where there is a market for sulphuric acid, the gases from the blende-roasting furnaces may be used for the purpose.

There are still great opportunities for improvement in the electrolytic process, which is to be expected, considering that the process has been in practical operation on a large scale for only about six years. One of the fields for improvement is the better treatment of the dross that is produced in melting the cathodes, which now we know to be rather inherent to the process and not to be corrected by the substitution of a closed furnace, such as an electric furnace, for the melting. The use of sal-ammoniac in the melting furnace prevents this dross from being returned to the electrolytic process, for it is undesirable to introduce any chlorine therein.

Such matters as the above are receiving careful attention and are bound to be solved in one way or another. All of the experience is tending to show, however, that electrolytic zinc is certain to become a powerful factor in the zinc industry and a serious competitor of distilled zinc.

During November, 1921, the first section of the new plant at Risdon was completed and was put in operation in a successful way. The entire plant will be ready for operation during 1922. Its capacity will be for the production of 45,000 long tons of spelter per annum.

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At Trail also extensions of plant are in process of being made. In Italy two small plants have been built, one at San Dalmazzo, the other at Vado Ligure. The Italians are giving earnest attention to this subject.

Reverberatory Smelting.—The Shasta Copper and Zinc Co. undertook to smelt the Bully Hill ore of Shasta County, California, in a reverberatory furnace, with the view to production of a copper matte and a zinc-oxide fume suitable for trade purposes. The fume proved to be of inferior quality, partly owing to the presence of sulphates, in spite of repeated refining; and the extraction of zinc from the ore was low on account of high scorification of zinc, leading to large loss in the slag, which assayed only a little above 40 per cent. in silica. This experience confirmed previous knowledge to the effect that in order to keep zinc oxide out of a slag the latter must be either very silicious, or very calcareous, or both. The slags, low in zinc, that are made in the electric furnaces in Trollhattan in Sweden assay 50 per cent., and upward, in silica.

Electrothermic Smelting.—I have not heard of anything particularly important having transpired in the field of electrothermic smelting since the date of my last annual review. The production of spelter by this method in Scandinavia in 1921 was small, but this appears to have been due to commercial conditions rather than metallurgical. Trollhattan was in operation and at that plant the size of furnace was increased so that it became possible to smelt as much as 12,000 kg. of ore per 24 hr. successfully in a single furnace. Glömfjord remained uncompleted. In the United States, Dr. Fulton continued his experimental work on the treatment of a briquetting charge in an electric furnace operated intermittently.

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PROGRESS IN ORE DRESSING AND COAL WASHING IN 1921

By Robert H. Richards and Charles E. Locke

General

The year 1921 has been a period of marking time. Very little has been done in the development of new processes, and the old processes have been inactive as regards metalliferous ores with the possible exception of silver. The companies have felt that during the period of depression they must not spend money on investigations or changes. A very few new mills have been erected.

The treatment of coal by wet tables, by dry tables, by froth flotation, and by the Trent process has received well-merited consideration and there is hope that a considerable improvement may result in coal-treatment methods and their efficiency.

A very important event was the settlement out of court of the main cases of flotation litigation, which actually occurred in the early part of 1922. The magnetite concentration enterprise of the Mesabi Iron Co. reached the stage where its possibilities can be demonstrated in a large-scale unit during the coming year.

As in the past the authors wish to acknowledge their indebtedness to the many individuals, firms and companies who have freely contributed material for this review.

Crushing and Grinding

Rock Breakers.—Nothing revolutionary is to be noted under this heading. Patents for the Mitchell breaker have been applied for in practically all foreign countries. The commercial development of this machine has stopped, at least temporarily. The fundamental principle appeared to be correct, but mechanical difficulties were met, especially in being unable to find a material for ball-races that would stand up.

Up-to-date crushing practice is exemplified by the new Copper Queen mill where a 66 by 84-in. Blake jaw-breaker set to 8 in., followed by two No. 9 Gates gyratory breakers set to 4 in., and these in turn followed by four 48-in. Symons disc crushers crushing to ¼ in., constitute the coarse-crushing machinery.[1]

It will be seen that jaw-breakers appear to be favored over gyratories

[1] J. B. Trimble, *Eng. Min. Jour.*, 111, 1079 (1921).

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as the primary breaker and this is also true in other new copper mills. At Tonopah, Nev., both jaw and gyratory types are used as primary crushing machines of such capacity that one 8-hr. shift will supply the mill for 24 hr. While either type of machine gives satisfaction, the consensus of expert opinion seems to favor gyratory breakers, since most of the recent installations here in newly built plants are gyratories. Secondary crushing is done by gravity stamps, and fine grinding by tube-mills. This crushing practice on Tonopah ores has been described and discussed by H. A. Burk.[1]

Symons Disc Crushers.—An interesting history of the Symons disc crushers is given by A. W. Allen.[2] He describes the old and new forms of the horizontal machine and states its advantages over other crushers. The modern vertical disc crusher is also described and its principle of operation is essentially the same as that of the horizontal machine. The disc-shafts are vertical. The machine consists essentially of a revolving central vertical sleeve which has an eccentric vertical hole. In this hole is a loose shaft carrying at its top end a convex flat disc on which rests a concave disc, flat on top. Above this flat or lower grinding disc, an upper disc is suitably spaced and supported by a frame which revolves in the same direction as the central sleeve. The concave disc carried on the vertical shaft when rotated causes rise and fall of the lower crushing disc which progresses around the circle. The ore to be crushed is fed through the center of the upper disc and falls on the lower disc; it is then thrown toward the periphery by centrifugal force, when it is crushed between them. The distribution of ore is more perfect than in the horizontal crusher.

Allen states that the disc crusher has found great advantage at Ajo, Ariz., and at Chuquicamata, Chile, in final dry crushing of low-grade copper ores to a size suitable for leaching, obviating the separation of sand and gravel from slime and colloid, and permitting the economical leaching of the whole product of the mine in one operation. He also advises the use of disc crushers for fine grinding of low-grade Chilean nitrate material for the same reason.

Rolls.—Rolls appear to be gaining headway and there is a marked reaction in favor of them as intermediate crushers. At the mill of the Engels Copper Mining Co.[3] sectional roll-shells of manganese steel have been installed and have proved entirely satisfactory. While no data are available as to costs per ton of ore crushed, it is believed the net cost will compare favorably with usual practice, judging from the tonnage already passed through the rolls.

[1] *Min. & Met.*, No. 172, 22 (1921).
[2] *Min. Sci. Press.*, 123, 849 (1921).
[3] A. B. Parsons, *Min. Sci. Press*, 123, 183 (1921).

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Stamps.—It is reported that in the Dome mill stamps, which had been discarded, are in use again. On the Rand stamps are still used at all the older mills and have been included in some of the most recent installations. It will probably require considerable favorable experience with other forms of grinders to dislodge them from the good favor of the Rand engineers. However, radical changes have been made in designing the New States Area mill in South Africa, although the machines have been thoroughly tried out in America. Stamps have been discarded in favor of horizontal Symons disc crushers which are followed by unusually large tube-mills, 6.5 by 20 ft. This has been made possible by enlarging the openings in the discharge grids of the tube-mills so that with a heavy original feed a large tonnage of unground, partially rounded pebbles, amounting to 30 to 40 tons per tube-mill per day, are discharged. These pebbles are screened out in a ½-in. trommel, passed through a set of rolls and returned to the tube-mill feed. This method materially improves the crushing efficiency of the tube-mills and makes a saving in capital cost over stamps. Following the usual practice with the hard banket gold ore of South Africa, mine rock in 4 to 7-in. blocks is used as a crushing medium in the tube-mills. The tube-mill product has 90 per cent. through 90 mesh.

An interesting application of the cementation process was made in the Heidelberg district to the repair of a new battery foundation. After only 48 hours' use of the new installation, the structure rocked so that operations had to be suspended. An inspection showed that a horizontal crack had developed severing the top 3-ft. from the lower 9-ft. portion of the mortar block and displacing portions of the concrete. Nine ⅞-in. holes were drilled into the top of the block penetrating the crack, and cement under high pressure (200 to 1000 lb. per sq. in.) was pumped into the holes, replacing the dislodged concrete and filling the crack. After ten days the stamps were started and the foundation gave entire satisfaction. The cost of the repairs was roughly $1000.[1]

Ball-mills.—These are maintaining their prestige, although suffering some competition from rod-mills.

In crushing the feed for ball-mills F. Benitez[2] has found that a Symons disc crusher delivers a far better product than does a breaker of the Dodge, Blake, or gyratory type. He also has been able to control within wide limits the quality of the discharge from an Allis-Chalmers ball-mill by varying the pulp density instead of plugging holes in the diaphragm.

His experience at Catému also throws some light on the use of ball-mills running on rollers. Two old Ferraris mills were bolted together to form one cylindrical ball-mill and great trouble was experienced with

[1] B. Schlesinger, *Jour. Chem. Met. Min. Soc. So. Afr.*, **22**, 76 (1921).
[2] *Min. Sci. Press*, **123**, 878, 883, 921 (1921).

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breakage and uneven wear of shaft and rollers. This may have been largely due to the fact that the rollers were not on the same shaft.

A. T. Fry[1] gives an interesting account of his attempt to grind a small amount of slag in a model ball-mill to such a degree that no more than 5 per cent. remained on a 150-mesh screen. The Hardinge company is building the cylindrical part of their mill longer to obtain capacity.

Wearing Parts and Adjustments of Ball- and Tube-mills.—At the C. O. D. concentrator at Kingman, Ariz., an improved form of lining for the rod-mills has been devised.[2] Pieces of 16-lb. rails and of hardened 1⅛-in. cruciform drill steel, each 3 in. long, were cemented in the mill, ends to shell, with the drill steel between the webs of the rails. The steel consumption was reduced from 3 to 2 lb. per ton of ore ground and the life of the liner is expected to be increased from 2 months to 12 months due to the slightly more rapid wearing of the rails, which prevents the rod load from slipping and causes the rods to cascade properly.

At the mill of the Cia. Minera del Mirasal, at Cusihuiriachic, Chihauhua, Mexico,[3] a ball-mill lining is made of standard 60-lb. steel rails. The rails are placed with heads toward the center of the mill and the heads are held about 2½ in. apart by means of washers 4 in. long which fill the space between the rails and which are bolted to the shell of the mill to hold the lining in place.

The cost of lining a Chalmers & Williams 6 by 4 ½-ft. ball-mill is compared with the new lining as follows:

Manganese-steel Lining.	
Weight, pounds	6,075
Cost, Chicago	$948
Cost, delivery	$271
Total	$1,219
Tons life	11,000
Cost per ton ground, cents	11

Mirasal Rail Lining.	
Rail weight, pounds	4,080
Washers, 96, pounds	960
Total weight, pounds	5,040
Second-hand rails cost at 3 cts. per lb.	$122
Washers and bolts	$ 66
	$188
Washers and bolts, good for two sets of lining, credit	$33
Net cost	$155
Tons life	16,000
Cost per ton ground, cents	1

H. W. Hardinge[4] has used scrap rails for a long time for lining the conical mill. For lining light ball-mills he has used sections of rail placed end to shell and cemented in place. The cost in consumption of this class of lining is given as less than ¼ ct. per ton, using balls not over 2 in. in diameter.

It has been found that plain liners cannot be used in a rod-mill, for the load will oscillate back and forth and wear out the liners in a short time.

[1] *Min. Sci. Press*, **123**, 737 (1921).
[2] M. S. Pressler, *Eng. Min. Jour.*, **112**, 30 (1921).
[3] P. G. Harrison, *Eng. Min. Jour.*, **112**, 778 (1921).
[4] *Eng. Min. Jour.*, **112**, 899 (1921).

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A new ball for ball-mills is the Austenite Diamond made by the Barney Floyd Foundry Co., which has stood up well under preliminary tests and is now being given a regular trial in actual crushing. It is a cast manganese-steel ball in which former difficulties of manufacturing a satisfactory product appear to have been overcome.

Rod-mills.—Rod-mills have a strong hold in the Southwest, being found in the new and remodeled Phelps Dodge plants and appearing in the proposed flow-sheet of the New Cornelia company's mill. The general scheme of all these plants is to crush in gyratory breakers and disc crushers to 1¼ in., followed by a single pass through Marcy rod-mills to ¼ in. This product is tabled and table-tailings ground to 48 mesh in closed-circuit rod-mills, which are followed by flotation and again tabling of the fine sands.

Regarding the limitations of rod-mills for fine grinding, the Mexican Corporation found in their Fresnillo cyanide plant that rod-mills did not grind efficiently to 200 mesh, and it is understood that their practice is to be modified to use rod-mills, ball-mills, and finally tube-mills in series. The difficulty seemed to be that in trying to grind to 200 mesh in the rod-mill the classifier return is of a syrup-like consistency which runs right through the mill again. If the classifier can be so controlled as to deliver a comparatively dry return product, then perhaps the rod-mill would grind it, but this question does not appear to be definitely settled.

The report of the best work of the Marcy rod-mill at the Fresnillo plant was that a 6 by 12-ft. mill treated 360 tons of ore per day with 15 per cent. on ¾-in. screen and, grinding in closed circuit with Dorr bowl classifier, delivered a final product with 70 per cent. through 200 mesh. The power consumption was 7.2 kw.-hr. per ton. At Yucca, Ariz., a 4 by 8-ft. Marcy rod-mill in closed circuit with Dorr classifier receives a feed with 7.6 per cent. coarser than 1½ in. and delivers a finished product with 75 per cent. finer than 200 mesh. The power used is 40 hp. for a capacity of 100 tons per day.

The development of the rod-mill has formed the subject of an article by E. H. Robie.[1]

A totally different type of rod-mill called the Forrester-Hendy is not yet on the market, but is undergoing large-scale testing. This mill has six cylindrical compartments arranged around a central shaft, each carrying its charge of rods. The mill is 5 ft. in diameter and 4 ft. long, with a 3-ft. discharge opening, and operates at 28 r.p.m. It is claimed to require but one-quarter of the power consumed by other types of the same capacity.

[1] *Eng. Min. Jour.*, **111**, 807 (1921). *Mining. Mag.*, **25**, 59 (1921). *Jour. Chem. Met. Min. Soc. So. Afr.*, **22**, 69 (1921).

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The Marathon mill was the pioneer rod-mill. Other designs have since been developed until today there are several standard mills.

The Cole-Bergman rod-mills have been improved mechanically by substituting S K F roller-bearings for ball-bearings. These roller-bearings have barrel-shaped rollers to take care of the self-aligning feature. The latest Cole-Bergman mill is 6½ ft. in diameter inside the shell and 12 ft. long. It is believed to be the largest roller-mill to date. To carry the weight of this mill on roller-bearings satisfactorily, several rollers are used connected together by having the roller-shafts pass through the hinged joints of a sprocket chain. The idea is somewhat similar to a short length of gold-dredge bucket chain or a traveling-chain bucket-conveyor, except that the two ends of the chains are firmly fixed in a supporting frame and the roller-bearings take the place of the buckets.

A new rod-mill of the trunnion-discharge type is the Dewco mill made by the Denver Engineering Works. This is at present furnished in the 4½ by 9-ft. size.

In general, the experience with the rod-mill seems to be that it cannot take feed as large as is often given to ball-mills, nor is it yet proved to be equal or superior to tube-mills where a product finer than 100 mesh is desired. The cost and consumption of steel appears to be less than for a ball-mill, as the manufacture of rods is better standardized than that of balls. Power consumption also appears to be less for rod-mills than for ball-mills of equal capacity and the former make less slime.

Very interesting tests are under way at the Hollinger mill on a 5 by 10-ft. Marcy rod-mill, an 8-ft. by 36-in. Hardinge mill, and a 7 by 6-ft. P. and M. mill made by the Worthington people. Results are not out yet, but should be available for next year's report.

Tube-mills.—The inefficiency of the long tube-mill has apparently been proved,[1] even when sliming is desired. The principle that a particle should be separated from the pulp as soon as practicable after it has been reduced to the desired size is recognized in using a comparatively short mill.

Crushing Practice and Theory.—There is still considerable difference of opinion between Southwestern metallurgists on the question of coarse crushing and fine grinding. The Inspiration single-stage idea from 1½ in. to 48 mesh in one step has given way to the extent of two steps of rod-mill grinding in the newer mills, but they have not yet come entirely to the point of accepting Miami practice of crushing in gyratories and rolls to ⅝ in. and finer, tabling, and then closed-circuit grinding to 48 mesh. The Inspiration ore has a high concentration ratio, and conse-

[1] A. B. Parsons, *Min. Sci. Press*, **123**, 775 (1921).

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quently they do not consider it worth while to try to save a small amount of copper in coarse condition. Practically all of their ore would have to be ground to 48 mesh in the end. An ore with a higher sulphide content warrants the stage grinding and tabling. On the other hand the Miami people on ore much like Inspiration go to the limit in stage grinding, using gyratory breakers and rolls, the latter being in closed circuit with Mitchell and Hummer screens. At the present time the entire situation is considerably mixed, so that it is difficult to decide which is the best method, but the authors of this review incline toward the stage method.

Harlow Hardinge[1] has discussed the high cost of continued use of obsolete grinding plants, and appeals to the operator to study fundamental principles of reduction. He enumerates the excuses for the obsolete plant and offers an excellent guide for the operator in purchasing grinding equipment. He also classifies grinding into various groups and discusses the limits of each. An excellent table of detailed costs of a plant for crushing medium-hard limestone at the rate of 15 tons per hour from 2 in. through 20 mesh with 50 per cent. through 100 mesh is given, together with a summary table and a table showing savings in cost of grinding by modern over obsolete methods.

For crushing asbestos ore in Quebec[2] jaw-breakers are used in preference to gyratory breakers as primary breakers. For breaking ore from 2 in. to approximately ¼ in., four different machines of the impact type have been used. The oldest and most common is the Laurie cyclone. The beaters or impellers revolve in opposite directions at 1900 r.p.m. The power necessary to operate it is high and it is expensive to keep in repair.

The second type, used by only a few mills, is the swing-hammer pulverizer. This mill requires a large amount of power and cost of repairs is high. It also has a great tendency to chop the fibre owing to clogging of the discharge-grating.

The best machine, and one designed especially for asbestos-bearing rock, is the Torrey Cyclone, a vertical-type crusher. Ore is fed through the opening and falls on a wearing-plate of manganese steel. From there it bounces and is caught by vanes or horizontal impellers, revolving at 1100 to 2000 r.p.m. The ore is hurled from these vanes into manganese-steel jaws, breaking the rock and liberating the fibre without cutting it. A 17-hp. motor will run one Torrey cyclone for an output of 12 to 15 tons per hour.

The fourth type of machine is the Jumbo or "fiberizer." This consists of a horizontal cylinder of steel plate with cast-iron heads and

[1] *Chem. Met. Eng.*, **25**, 229 (1921).
[2] W. D. Hubbard, *Min. Sci. Press*, **122**, 932 (1921).

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with liners made of steel plate. The cylinder is in halves, which are hinged together to facilitate opening for cleaning and repair. Through the center of the cylinder runs a shaft with eight arms of heavy bar-steel, carrying on the ends chilled-iron beaters, the faces of which are at such an angle that the material fed into the machine is driven to the discharge end as the shaft and arms are rotated. The machine gives satisfaction and is used in a number of mills. Less attrition results than with the Laurie machine, but it is not as efficient.

The new South mill of the Homestake company, referred to last year, is now under construction. The practice follows strictly the principle of screening out the undersize preceding every crushing step. Thus a 9-in. grizzly precedes the 36 by 48-in. jaw-breaker underground; a 3-in. grizzly precedes the No. 6 Gates gyratories in the mill; a 2-in. grizzly precedes the No. 6 Gates gyratories; and a ½-in. trommel precedes the stamps.

At the mill of the Engels Copper Mining Co.[1] Marcy mills (No. 86) equipped with manganese-steel liners and chrome-steel screens, fed with 5-in. chrome-steel balls and driven by motors direct-connected to the pinion shafts, are giving satisfaction.

As to practice on the Rand, G. A. Denny and H. S. Denny, who have for years advocated the substitution of other machines for stamps, state[2] that while many of the companies can not yet make the change some are advocating the elimination of at least part of the stamp equipment and the introduction of tube-mills to handle the fines from preliminary grizzlies that formerly went to the stamps. At one property it is claimed that the complete elimination of stamps is advised and the substitution of (1) stage crushing with coarse and fine crushers, followed by rolls, ball-mills or edge runners, with final grinding by tube-mills or grinding-pans; or (2) stage crushing with coarse and fine crushers, followed by tube-mills only.

In the first case, the combination would be designed to reduce the ore to about 30 mesh, and this would be further reduced in the fine-grinding plant to 150 to 200 mesh. In the second case, a coarse product of about 1-in. cubes maximum would be fed direct to the tube-mills.

The advantages of substituting tube-mills for stamps are given as follows: (1) The combined capital outlay in crushers and tube-mills to reduce 100 tons of mine rock to minus 90 mesh is approximately 50 per cent. less than when stamps are included. (2) The ore-reduction costs are 20 to 40 per cent. less because of the reduced charges, for labor, power, maintenance, depreciation, and amortisation. (3) The final

[1] A. B. Parsons, *Min. Sci. Press*, 123, 183 (1921).
[2] *Min. Jour.*, 135, 722, 758, 796, 893 (1921). *Can. Min. Jour.* 42, 896 (1921).

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product is in a better condition for the extraction of the gold in the subsequent metallurgical operations and therefore the gold losses in the residue are smaller.

Screening, Classifying and Settling

Screens.—Vibrating screens now have the call and are competing all along the line, wet and dry, and coarse and fine. The Mitchell and Hummer are still in the lead, although the remodeled Cananea mill uses the Cole type. The Mitchell and Hummer screens installed for comparison at the Miami mill are reported to have both worked out satisfactorily.

The success of these types has led to other devices of a similar nature. At the St. Joseph lead mills in Missouri the Delano screen is a mechanically operated vibrating screen of simple construction, made in their own plant, and operating either wet or dry. One of these dry screens does the work of three 9-mm. trommels, that is, 500 to 600 tons in 24 hr., with no sacrifice in quality of product. Its screening efficiency figures out 90 to 95 per cent. Wet screens, each 3 by 5 ft. in area, with Toncap screen cloth of 0.07-in. opening, are operated in closed circuit with the ball-mills, and show an average screening efficiency of 92 per cent.

Another screen is the Nazarian, which obtains uniform vibration and an initial hammer action through a mechanism consisting of an unbalanced pulley to give the vibration, combined with a loose eccentric ring to give the jar. It is possible so to adjust the mechanism as to cause the ore to hop along the screen surface. This apparatus is still in the development stage, but looks promising. At the Federal lead mill in Missouri 20 sq. ft. of this screen with 2-mm. holes treated 800 tons per day, doing the work of two trommels which had 220 sq. ft. of screening surface. The wear was figured to be one-sixth that of the trommels and the power required was much less. It ran at 1200 to 1500 vibrations per minute.

A new Mitchell screen, Type 5, with vibrator suspended above the screen, has been developed but has not appeared on the market. Mitchell screens are to replace the stationary screens at the Nevada Consolidated mill.

Some of the story of the development of the Mitchell screen has been told by B. A. Mitchell and G. B. Rosenblatt.[1] Vibration by hammers was found to be mechanically impossible at the high frequency desired; a pneumatic vibrator such as is used in foundries gave the hammer

[1] *Min. Sci. Press*, 122, 419 (1921).

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effect, however, and at a high speed, but it was found that the path of the vibrating wires of the screen was at right angles to the plane of the screen. On the other hand vibration by an unbalanced rotor such as an unbalanced pulley or the Mitchell vibrator, which incorporates the same idea, causes the paths of the vibrating screen wires to approach circular orbits as the frequency of vibration increases. This makes for the best screening action with minimum wear and blinding. Using an unbalanced rotor a critical point was found at about 2000 vibrations per minute below which the vibration of the screen was irregular and unsatisfactory.

The Simplex screen was very briefly referred to last year as the Wullstein gravitation screen. It appears to possess considerable merit and good reports are received from the mills where it has been installed. It can best be described by likening it to a series of combs, each comb being set on a slope with the open ends of the teeth at the lowest point. It differs from a comb in that while the bases of the teeth are all in the same plane, the tips are zigzagged up and down. In other words the tip of every alternate tooth is a little higher than its neighbor on each side. The effect of this arrangement is to produce openings between the teeth which gradually widen from the bases of the teeth to the tips, and as the ore slides down by gravity over these tapering spaces the opportunity for it to stick in the opening and blind the screen is practically nil. As each section or comb is of comparatively short length down the slope the total screen length is made up of several sections, which may all have the same size of opening or may vary from fine at the upper end to coarse at the lower end.

The efficiency and capacity of trommels and flat screens are discussed by J. S. Watts,[1] insofar as they are affected by length, width and thickness of ore-bed, size of holes, and character of feed. Along a similar line an experimental investigation of the relative merits of plate and wire screens and the problem of blinding has been made by W. Gross.[2]

Classifiers.—Development has been mostly along the line of intermittent-discharge devices and Dorr apparatus.

The new Elder classifier works along the principle of the Allen cone in having a float in a central compartment to operate intermittently the discharge-plug at the bottom, but the Elder is cylindrical and has a horizontal screen a few inches above the bottom. The discharge-plug is in the center of the screen. Hydraulic water from below rises through the screen and overflows around the circumference of the cylinder at the top. Whenever the bed of sand accumulates to a certain height the

[1] *Can. Min. Jour.*, **42**, 271, 623 (1921).
[2] *Metall u. Erz*, **18**, 619 (1921).

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flow of feed-water becomes restricted, the float rises, the spigot-plug opens and remains open until the sand bed lowers to the point that the float drops back.

Another form of automatic cone classifier underflow regulator is that in use at Apex Plant.[1] It operates by counter-balance and pulp-flow friction. The counter-weight, which is adjustable, serves to keep the spigot-valve open and balances it against the normal underflow of the classifier. When this becomes thin, increasing the rate of flow, the increase in friction and pressure on the valve is sufficient to throttle the flow until equilibrium is again established. The device is extremely sensitive, maintaining an even flow to the tube-mill. The overflow of the dewatering cone is likewise satisfactory.

The way that the Boylan cone works out this effect is by suspending the entire cone from the short end of a horizontal lever having a fixed fulcrum. The long end of the same lever is connected by an adjustable rod and lever to the vertical plug which fits into the spigot-opening at the bottom of the cone. An adjustable counter-balance weight on the long end of the lever is so set as to keep the valve plug closed when only the normal amount of solids is in the cone. As sands accumulate in the bottom of the cone, which by the way has the well-known diaphragm principle, the combined weight of the cone and its contents increases, thus pulling down the short end of the lever and simultaneously raising the long end with its counter-weight. The raising of the long end pulls on the connecting rod and opens the plug spigot, which remains open until the decreased weight of sand in the cone acts to reverse the entire operation of the cone, lever, and counterweight. The machine costs from $300 to $400 and repairs are practically nil, one cone through which 55,000 tons has been run requiring only a new conical valve costing 45 cts. This classifier is claimed to be used in the Joplin-Miami district in place of trommels, overshot, impact and other mechanical screens, mechanical and hydraulic classifiers, dewatering boxes, and similar devices.[2]

Dorr Apparatus.—Owing to the greater efficiency that can be obtained by using the Dorr Bowl classifier, a number of these were installed during the year in both base- and precious-metal mills. The results reported definitely show a much better elimination of undersize with a natural result of better grinding when this classifier is used in closed circuit. The following shows the operating results of an 8 by 25-ft. Model D Dorr classifier with a 12-ft. bowl used in closed circuit with a roller-mill at the Fresnillo mill, handling 500 tons of original feed per 24 hr.

[1] H. Brazier, *Jour. Chem. Met. Min. Soc. So. Afr.*, **22**, 74 (1921).
[2] P. R. Coldren, *Eng. Min. Jour.*, **112**, 79 (1921).

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Mesh.	Cumulative Percentages.		
	Feed.	Sands.	Overflow.
+20	10.0	10.0	....
+40	30.6	41.6	....
+60	47.6	58.0	0.4
+80	68.8	77.2	5.6
+100	80.8	92.4	18.0
+150	87.0	96.0	34.4
+200	89.4	98.4	44.8
−250	10.6	1.6	55.2

The following data from one of the large copper companies show an increased application of the Dorr Bowl classifier, emphasizing its value ahead of tables, not only so as to give them a slime-free feed, but also on account of the preliminary concentration accomplished by the classifier itself. The ore is ground in closed circuit to 48 mesh, using ball-mills and Model D Dorr Simplex classifiers. After flotation the tailings go direct to two 12-ft. bowl classifiers, the overflows from which pass out as tailings while the sands go to tables.

	Feeds.	Sands.	Over-flow.	Table Concen-trates.	Table Tails.
Weight, tons	1105	240	965	1.55	238.5
Total copper, per cent.	0.235	0.375	0.165	16.86	0.266
Oxide copper, per cent.	0.092	0.063	0.110	.....	0.049
Sulphide copper, per cent.	0.143	0.312	0.055	.....	0.217

The suction-box Dorr classifier is a new development which is evidently finding favor as a means of reducing the moisture in table concentrates. The work done by the Utah Copper Co., using four classifiers 6 ft. wide, shows that the moisture in the fine table concentrates is reduced to about 8 per cent., whereas without the vacuum they are discharged with from 12 to 15 per cent. At the Chino mill a considerable saving in the cost of drying the table concentrates is effected, the moisture being reduced from 15 or 18 per cent. to approximately 8 per cent. At the St. Joseph Lead Co.'s mill, two Dorr classifiers 8 by 25 ft. with 12-ft. diameter bowls are used to dewater jig tailings of 9 to 2-mm. size, which are reduced to 6 per cent. moisture and pass to belt-conveyors for stacking.

Dorr classifiers have obtained a foothold on the Rand in South Africa. They have been selected in the New States Areas gold mill in the place of return cones heretofore universally used for classification in that district.

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The tray types of Dorr thickeners are being more extensively used. The six 75-ft. two-compartment tray thickeners at the new Copper Queen mill have been installed, as has also a 200-ft. diameter peripheral-drive Dorr thickener. Dorr tray thickeners 50 ft. in diameter by 22 ft. deep with four compartments are now in successful operation. After extensive testing the Phelps Dodge company has installed twelve precipitating thickeners, each 24 ft. in diameter, in connection with their heap-roasting operations at Bisbee.

The Dorr Hydroseparator is distinguished from the Dorr thickener merely by the work that it does of separating water and slime from the coarser solids while the thickener settles the solids from the water. In last year's review an error appeared in that the Dorr Washer, which is a combination of a Dorr classifier with a trommel, was referred to as a Hydroseparator. The Dorr Hydroseparator finds application especially on coal, but is also used in other special cases. For example, the Hollinger ore contains a certain portion of schistose slime which is settled with extreme difficulty, so that if all the slime were sent to the thickeners in the counter-current decantation plant the thickeners would have to be very large. Accordingly this fine slime is separated from the rest of the finely ground ore by Hydroseparators, and is settled and treated on Moore filters. The underflow of the Hydroseparator then goes to the thickeners. In coal the finest sludge goes into the Hydroseparator overflow and is waste, while the Hydroseparator spigot goes to tables.

In regard to Dorr Washers, there is nothing new to report on their work in iron-ore washing. An interesting application of this machine is now being lined up. It will be used in closed circuit with a grinding mill to make

Mesh.	Feed.			Sands.			Overflow.			Table Concentrates.			Table Tails.		
	Weight, Per Cent.	Per Cent. Copper.	Per Cent. of Total Copper.	Weight, Per Cent.	Per Cent. Copper.	Per Cent. of Total Copper.	Weight, Per Cent.	Per Cent. Copper.	Per Cent. of Total Copper.	Weight, Per Cent.	Per Cent. Copper.	Per Cent. of Total Copper.	Weight, Per Cent.	Per Cent. Copper.	Per Cent. of Total Copper.
48	0.9	0.38	10.4	3.2	0.41	3.5	0.1	.....	.....	0.9	23.21	5.8	3.6	0.40	5.3
65	5.5			25.2	0.34	23.0	0.5	.....	.....	3.3			21.3	0.33	25.9
100	13.1	0.36	20.2	40.8	0.33	36.1	4.9	0.16	5.5	18.4	30.00	33.1	43.9	0.27	43.7
150	8.7	0.25	9.3	13.0	0.41	14.5	7.9	0.14	6.9	20.0	20.73	24.9	12.3	0.24	10.9
200	13.9	0.22	13.1	10.7	0.52	14.9	15.7	0.13	12.7	31.0	13.58	25.2	11.7	0.21	9.1
−200	57.9	0.19	47.0	7.1	0.43	8.2	70.9	0.17	74.9	26.4	7.00	11.0	7.2	0.19	5.1
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a clean product through 20 mesh washed free from slime, the trommel oversize returning to the mill for regrinding and the overflowing slimes going to flotation.

Applications of Dorr apparatus to coal are described later under *Coal Washing.*

Dewatering.—At the Santa Barbara mill[1] a dewatering system is used consisting of seven concrete tanks 4 ft. 6 in. high, 12 ft. wide, and 35 ft. long. A steel door is provided in one end of each tank to allow concentrate to be taken out with wheelbarrow. The bottom is provided with a steel grating 3 ft. 2 in. wide by 28 ft. 2 in. long, upon which is placed cocoa filter matting for drainage. A concrete platform outside the tank and level with the bottom permits direct wheeling of the concentrates to railroad cars.

Theory.—Some experimental results on settling velocities of particles in water have been published by K. Sundberg.[2]

Hand Sorting, Jigs and Tables

Hand Sorting.—The application of hand picking and its relative merit as compared with coarse jigging is still subject to differences of opinion. F. Burklein[3] has contributed his ideas on this problem.

Although hand sorting of gold ores on the Rand has been pretty thoroughly discussed in the past a new idea has been brought out by W. A. Caldecott,[4] who suggests that mill men can determine the amount of clean waste that they put through the mill by checking up the average value of the clean vein material and of clean waste from mine samples and comparing this with the average of mill feed.

Then 100 × mill-feed assay = (percentage of reef × its assay) + (percentage of waste × its assay).

Jigs.—There has appeared a tendency to devote little attention to jigs during the past few years. This condition may be ascribed to the call for tables and flotation. The jig nevertheless remains a machine capable of doing the highest grade of work. It can make a closer and cleaner separation than tables and it is refreshing to have the jig begin to receive again the attention that it merits. W. Gross and W. Goy[5] have made an exhaustive critical experimental study of jig operation, dealing especially with the advantages of jig screens of the Schubert bar type and the Schuchard zigzag screen. Further, the theory of jigging and the action of particles on a jig bed has been discussed mathe-

[1] F. M. Heidelberg, *Eng. Min. Jour.*, **112**, 1050 (1921).
[2] *Jern Kontorets Ann.*, p. 211 (1921).
[3] *Gluckauf*, **57**, 1171 (1921).
[4] *Jour. Chem. Met. Min. Soc. So. Afr.*, **22**, 64 (1921).
[5] *Metall u. Erz*, **18**, 121, 152, 177 (1921).

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matically by H. von Sanden,[1] while Prof. G. C. Bring has been making an experimental study of the principles of jigging and the action of particles in a jig bed and has presented the whole matter in a paper on "Theory of Jigs."[2]

The Neill jigs continue to find application in recovering auriferous and platiniferous black sands from the slimes in connection with hydraulicking and dredging operations.

The Henry jig made by the Webb City and Carterville Foundry and Machine Works is a novel apparatus which has a circular tank with a central plunger and an annular jig screen all around. The jig tank is mounted on rollers and the principle resembles the revolving slime table in that ore is fed at a fixed point and is carried along by the motion of the jig and is at the same time jigged by the plunger action. During its rotation it is subjected to two removals of the upper layer by skimming buckets on a wheel. The first skimming removes clean gangue and the second takes off middlings and leaves clean concentrates to go into the hutch. One advantage which this jig possesses is that there is no horizontal current of water to carry fine concentrates along the surface into the tails, jigging being done entirely in still water as far as any horizontal current is concerned.

Tables.—Kirtley riffles of galvanized iron with broad bases so as to entirely cover the linoleum have shown a decided advantage in the Replogle mill near Wharton, N. J., over wood riffles. They give longer life, reduced costs, and greater efficiency.[3]

For tabling a complex ore in the Bunker Hill mill in Idaho the ordinary Wilfley riffling is supplemented by covering the smooth portion of the table with groups of additional short lengths of riffles which are really extensions of the regular riffles, but which are separated from them by short gaps. Further there are short open spaces between the groups, the line of these open spaces being parallel to the diagonal end line of the regular riffles. In other words if one starts at the mechanism end of the table, first comes a regular riffle, then a short gap, then a short length of riffle, then another gap and riffle, and so on until the concentrates end is reached. The riffle nearest the wash-water side of the table has six gaps; that at the tailings side has only one, owing to the diagonal lines of the gaps. This arrangement makes a wider fan of concentrates and cleaner separation.[4]

While canvas tables have pretty nearly gone into the discard, their use is still found in exceptional instances, especially in gold mining. For example, at the Globe and Phoenix mill in Southern Rhodesia the pulp

[1] *Gluckauf*, **57**, 1273 (1921).
[2] *Jern Kontorets Ann.*, p. 449 (1921).
[3] W. R. Canton, *Eng. Min. Jour.*, **112**, 180 (1921).
[4] C. Y. Garber, *Eng. Min. Jour.*, **111**, 788 (1921).

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from the grinding pans is concentrated on rectangular canvas tables 19 ft. long and 53 ft. wide, with a step or drop half-way down the slope.[1]

The Ondra concentrator, which is reported to be re-treating old tailings at the May mine on the Rand, is really a combination of classifier and screen. The ore is fed to the sloping sorting column of the classifier, which has outlets at different heights which serve to draw off successively lighter portions. These in turn go to shaking screens varying from coarse for the heavy classifier product to fine for the light. The oversizes of the screens are clean waste; the undersizes are further treated by cones and Wilfley tables.[2]

In considering the physical bases of tin dressing, R. T. Hancock[3] has devoted much space to the principles underlying the action of flowing films of water on particles lying on the separating surfaces of tables, vanners and sluices, interpreting the experimental results of various investigators.

Amalgamation, Magnetic and other Special Processes

Amalgamation.—The history of amalgamation on the Rand has been traced by G. A. and H. S. Denny,[4] who state that the decreased amount of gold obtained by amalgamation after adoption of tube-mills and circulating cyanide solution clearly points to the abandonment of plate amalgamation because of the fact that with the fine grinding necessary for the recovery of high percentages of the gold present the "all sliming" plant can without additional expense recover up to 96 per cent. of the gold contents of the ore, including that now saved by amalgamation, and eliminating theft of amalgam, which has been a source of great loss. Their views are probably radical, and amalgamation will doubtless continue on Rand ores, although it is significant that amalgamated plates find no place in the flow-sheet of the New States Areas gold mill in the Far East Rand district, where ore is less free-milling than in the Central Rand district. The yield by amalgamation is frequently as low as 35 to 40 per cent. on these ores and straight cyaniding is the more suitable process since it saves the cost of installing and operating plates.

The old idea that oil is absolutely taboo in amalgamation has been somewhat upset by the reports that successful amalgamation is being done not only after flotation but also when the mill-water from flotation is repumped to the mill. The explanation probably is that only a small amount of oil is present and it is largely soluble oil which may have less deleterious effect on mercury than insoluble oil.[5]

[1] V. E. Robinson, *Jour. Chem. Met. Min. Soc. So. Afr.*, **21**, 117, 169 (1921).
[2] *Eng. Min. Jour.*, **112**, 815 (1921). From *So. Afr. Jour. Industries.*
[3] *Mining Mag.*, **24**, 80 (1921).
[4] *Min. Jour.*, **135**, 866 (1921).
[5] L. C. W. Graefe, *Min. Sci. Press*, **122**, 593 (1921).

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Amalgamated plates in poor condition from bare spots and copper stains may be restored to first class shape by the use of an amalgam of mercury and 1 per cent. potassium.[1]

Magnetic Separation.—The progress of the Mesabi Iron Co. is being closely watched. The first unit has been constructed and will be fully tried out in 1922.

The Beach Glen magnetite concentrating plant has been described by E. C. Krentzberg.[2] The special features are (1) washing the ore at the start to remove fines for later treatment; (2) no drying; (3) dry magnetic machines for material coarser than ¼ in. and wet magnets for material under ¼ in.; (4) recrushing of coarse middlings in rolls.

A demagnetizer for removing residual magnetism from particles of magnetic products in order to break down clots and flocculated material so that further separation, either wet or dry, may act on individual particles has been described by Davis and is in use in several magnetic concentrating plants. Its principle is merely passing the ore through a coil carrying an alternating current. Davis has also written up his magnetic-concentration testing work on Mesabi magnetite ore and included also tests on other magnetites and hematites both by raw treatment and roasting treatment, and has added thereto collateral information on principles of magnetic separation, descriptions of apparatus, characters of ores, and typical flow-sheets so as to make a well-rounded bulletin which should be consulted by any one interested in magnetic separation.[3]

Electrostatic.—Huff electrostatic machines have had the defect of small capacity, and to remedy this a 16-roll machine has been developed which has a capacity of 4 tons per hour, and is adapted to the treatment of the coarser-sized materials from 0.5 in. to 10 mesh. It is making a satisfactory separation of rock salt commercially and has also been found to be applicable to the separation of quartz from feldspar. For generating the high-voltage current a new Kenetron apparatus is supplied which has no moving parts, is more compact, more efficient, and is not troubled by dust.

Patents for electrostatically separating minerals when suspended in liquid mediums have been granted to H. S. Hatfield.[4]

Pneumatic.—A rough form of air jig operated by a hand-bellows device is used for recovering gold from the dry placers of the Johnnie district, Nevada.[5]

[1] C. Flury, *Eng. Min. Jour.*, **112**, 578 (1921).
[2] *Iron Tr. Rev.*, **69**, 1285 (1921).
[3] E. W. Davis, *Bull. Minn. Sch. Mines. Expt. Sta.*, **9**, (1921).
[4] *Mining Mag.*, **25**, 189 (1921).
[5] C. Labbe, *Eng. Min. Jour.*, **112**, 895 (1921).

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Centrifugal.—The Eccleston centrifugal concentrator, which was being tested out at Tucson on slimes below 200 mesh, has been dropped temporarily, although the results obtained were promising. Like any other new apparatus it requires time and effort to bring it to mechanical and economic perfection. Incidentally this machine seems to offer some possibility as a rapid and efficient filtering or dewatering device for slime and flotation concentrates.

Heavy Solution Action.—These are referred to later under *Coal Washing.*

Friction.—The use of the variation in the coefficient of friction of minerals is a physical property which has been experimentally investigated by S. Nettleton[1] with the idea of applying it to ore concentration, and some fairly good results have been obtained. This is really the principle on which automatic slate-pickers work in coal plants. The writers of this review tried this method at one time for separating mica from quartz and feldspar. A product fairly clean from mica was obtained, but the mica product contained a lot of the other two minerals.

Flotation

General.—The leading events in flotation during the past year have been the settlement of several important lawsuits and the investigation of the possibilities of applying this process to coal. Along metalliferous lines flotation has become either the sole concentration method or an important auxiliary, so that from the practical side the chief lines of progress are in adjustments of the methods and machines for maximum efficiency.

Application.—No extensions in the field of sulphides have occurred, although in investigations of South African banket ore at the Rand Mines laboratory, F. W. Wartenweiler[2] used flotation, not with the idea of treating the ore that way, but to obtain some special products for examination. Wood tar and turpentine in acid circuit were used and a clean separation of the pyrite was made so that the tails were practically free from sulphides. The free gold floated with the pyrite.

The results indicate that the tendency to throw more responsibility on cyaniding and less on amalgamation for the gold recovery is warranted, and also that for highest extraction fine grinding is advisable.

This work has had the effect of turning the attention of the Minerals Separation company to the possibilities of flotation on Rand ores. Test results indicate that extractions of from 93 to 98 per cent. of the gold

[1] *Mining Mag.*, **25**, 258 (1921). From *Midland Inst. Min. Civ. Mech. Eng.*
[2] *Jour. Chem. Met. Min. Soc. So. Afr.*, **21**, 217; **22**, 24, 35, 106 (1921). *Mining Mag.*, **25**, 189 (1921). *Min. Sci. Press*, **123**, 627 (1921).

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can be obtained by flotation. In one case an ore assaying 1.1 oz. per ton gave a residue assaying 0.028 oz. per ton with an extraction of about 97 per cent. The concentrates can readily be cyanided.[1]

The use of tables after flotation was earlier in vogue to serve as a check on the work of the flotation machine, but a new innovation is their use ahead of the flotation machines as "pilots" or barometers to guide the mill man in regulating the flotation operation. He is enabled to detect immediately any changes in richness or character of the feed and to change the reagents or feed-rate to suit. The products from the tables are discharged into a single launder and flow back to the circuit from which the feed was diverted.

Oxide Ores.—Treatment of oxide ores by filming appears to be at a standstill. The Shattuck Arizona mill on carbonate lead ores is reported to be shut down. The Santa Barbara mill, described later, is still experimenting. Some experimental work has been carried on by the Anaconda Copper Co. on some old semi-oxidized tailings dumps using hydrogen sulphide for gassing the pulp, but so far the results have not been very satisfactory.

The latest reports in the flotation of cassiterite are that while patents have been granted to cover the operation and claims are made that it can be done, no commercial plant is being installed in Cornwall. It is apparently another case where success in the laboratory cannot be duplicated in practice. The chief difficulty is that the agent used floats up mispickel and pyrite and a good deal of the chlorite, thus giving a low-grade concentrate which has to be re-treated.

A patent for the treatment of cassiterite by sulphonated fatty or resin acids has been granted to M. T. Taylor and J. W. Partington.[2]

Mixed Oxides and Sulphides.—The "mixed ore" problem of how to deal with the mixed sulphide and oxide copper ores of the Southwest can be said to be nearer solution. Straight flotation or straight acid leaching which work satisfactorily on sulphide and oxide ores respectively cannot be applied on the mixed ores. It is also pretty generally conceded that the many attempts to use filming flotation have only demonstrated that this method is not commercially applicable. It seems to work all right in the laboratory, but not in practice. Perhaps the trouble may come in the mill from building up of unfavorable constituents in the solution. The most promising method of solution at the present time is by the use of sulphur-dioxide leaching, which is under investigation by the U. S. Bureau of Mines Station at Tucson in conjunction with the Miami and Arizona Copper companies.

It is pretty well established that with sulphur-dioxide leaching some

[1] E. Homersham, *Mining Mag.*, **25**, 387 (1921). From *So. Afr. Min. Eng. Jour.*, Oct. 28, 1921.
[2] *Mining Mag.*, **24**, 251 (1921).

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beneficial sulphuric acid is formed by the oxidizing action of ferric salts on sulphur dioxide at higher temperatures.

The method of applying sulphur dioxide is to grind the ore to 48 mesh and to treat it in drums with sulphur dioxide and water. Air is then blown through to remove sulphur dioxide and to give oxidation. The copper is precipitated on iron and floated, or perhaps it may be found more advantageous to leach it. The sulphide copper is preferably floated out before the sulphur-dioxide treatment, or it may remain in and be floated with the metallic copper.

Where attempts have been made to float precipitated metallic copper along with the sulphide, an acid solution has been found necessary. A neutral solution or the presence of ferrous sulphate or of sulphur dioxide has a bad affect on flotation. The last named can be blown out by air.

When ordinary iron is used to precipitate the copper the precipitate does not float readily, so that sponge iron is necessary as a precipitant; and the problem has not been entirely solved of making sponge iron on a commercial scale.

The Inspiration method for mixed ores is a dual process. The ore is crushed to ¼ in. and first leached with sulphuric acid and precipitated electrolytically. The leached tailings are then ground to 48 mesh and the sulphides floated out.

At Catému, Chile, an ore which is a mixture of oxides and sulphides is treated. Sodium polysulphide in saturated solution is used for filming, and is introduced into the sixth agitating-box of the flotation machine, the amount added being regulated closely to prevent killing the froth. Also sodium silicate and sodium hydrate are used for deflocculation.

Many oils have been used in testing the ore and finally Mexican crude petroleum was selected as a collector and Minerals Separation fuel oil as a frother. Pine oil, refinery-acid oil, and pine tar are used as auxiliary floating media. The recovery of the sulphide copper in 1920 was reported to be 95 per cent., and of the oxide copper 66 per cent. The total copper recovery was 91 per cent.

Selective Flotation.—The separation of chalcopyrite from pyrite is successfully made by the Tennessee Copper Co., which is introducing flotation for fines. Likewise tests in the laboratory of the Canadian Department of Mines at Ottawa on low-grade Hidden Creek ore of the Granby company showed that a selective flotation of chalcopyrite from pyrite could be made commercially.

The basis for the remodeling of the Cananea mill is the differential flotation which has been obtained, whereby barren pyrite is eliminated from the copper sulphides and the ratio of concentration very nearly

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doubled over the former gravity scheme. The concentrate is smaller in amount, the mill is simpler, the extraction does not suffer, and finally the cost of making copper is reduced 2 cts. per lb. Nevertheless the remodeled mill can easily recover the total sulphide in the ore in case the differential flotation does not work out in practice as expected.

Selective flotation of the Sullivan ore at Trail has entirely replaced magnetic separation. This ore has lead and zinc sulphides in very fine dissemination, 200 mesh or finer, together with pyrite and pyrrhotite in varying proportions. The zinc is in the form of marmatite containing about 10 per cent. iron. The insoluble is about 4 per cent. and the sulphur 32 per cent. The ore is reduced in breakers and rolls to ¾ in. and then the daily tonnage of 1000 tons goes to an 8-ft. by 48-in. Hardinge ball-mill, where it is reduced in a single pass to 4 per cent. on 35 mesh and 45 per cent. through 200 mesh with a steel-ball consumption of 0.29 lb. per ton and a lining consumption of 0.07 lb. per ton. This product is distributed to three 5 by 18-ft. ball-mills working in closed circuit with Dorr classifiers. The overflow is fed to a 20-cell 24-in. standard Minerals Separation machine, which makes a rough lead separation and sends the residue to a second machine, where conditions are changed so as to float the zinc and make a tailing which is re-treated in a subaeration Minerals Separation machine, from which a low-grade zinc concentrate is produced which is reground and then cleaned in a small standard flotation machine making a final tailing and a zinc concentrate. The rough lead concentrate is cleaned and recleaned on two subaeration Minerals Separation machines, producing final lead concentrate and cleaner tailing which is returned. Some lead escapes into the zinc and the zinc concentrate is tabled to recover some of this and some iron which floated during the zinc flotation. Deister-Overstrom, Plat-O, and Wilfley tables are used for this purpose. A mixture of pine oil and creosote is used as a frothing agent.

Coghill in his work on complex ores has come to the idea that it is necessary to re-treat both concentrates and tailings in order to make a high-grade concentrate. The presence of gangue is bad for selective work, so that it is desirable either to eliminate the gangue by tables or float all the sulphides together before undertaking to make a selective flotation. An acid bichromate of soda solution has the effect of deadening the galena and pyrite so that these two minerals will not float up with blende. This is much better than neutral or alkaline solution.

Interest still continues in this country in the possibilities of the Bradford sulphur-dioxide process, and some experimental installations are under way, but have not yet reached the point where results can be reported.

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The various methods and reagents that have been proposed for differential flotation have been summarized by A. W. Fahrenwald.[1]

Machines.—No radically new machine has appeared, but such new machines as have been brought out use the fundamental principles of the older machines and differ mainly in design or in combination of principles. The large new mills appear to be using air cells, while in small mills mechanical agitation is more common.

Experiments are being conducted with very shallow pneumatic cells with a view of reducing the air pressure and saving power thereby. The main question seems to be whether such shallow cells are capable of easy control.

The new standard Callow rougher cell is 36 ft. long and consists of twelve 3 by 3-ft. units. It is easier to repair and more efficient than the older type of Callow cell.

At the new Copper Queen concentrator[2] Callow machines of the Inspiration type are to be used. The roughers have twenty-two cells with a total area of 231 sq. ft. and can handle 2.11 tons per sq. ft. per 24 hr., 1.92 tons of this being returned from the cleaners. The cleaners each consist of six cells with a total area of 83 sq. ft. and can handle a feed of 1.62 tons per sq. ft. per 24 hr. Flotation-machine boxes will be made up of concrete slabs 6 to 10 ft. wide, 2½ in. thick and from 10 to 20 ft. long, reinforced with ¼-in. rods. They will be cast flat and bolted in place when being erected. Grooves 3 in. wide in the floor provide ½ in. caulking. The best design for the air bottom is stated as not yet decided.

The Allen cell[3] used at the Smuggler Union plant is a simple and convenient cell of large capacity. The largest single cell is a wooden box, 40 ft. long and 36 in. deep; the bottom is 30 in. wide and has no slope whatever. The sides are inclined inwardly so that, at the top, the cell is about 18 in. wide. This feature is credited with affording a decided advantage in obtaining a clean concentrate.

The Atkins flotation machine, made by the Colorado Iron Works, resembles the K. and K. somewhat in form in that it is horizontal and divided into several compartments or cells by cross partitions. Each compartment consists of a square frothing chamber supplied with an air-tight cover containing an air-inlet valve which may be regulated, and a connecting spitzkasten. A horizontal shaft runs through the frothing chambers from end to end of the machine and makes 55 r.p.m. On the shaft in each compartment are fastened side by side the rotor or aeration member and the diffusion member. The former is like a multiple-scoop feeder for a tube-mill, and is so placed that at their highest points

[1] *Idaho State Bur. Mines Pamphlet*, No. 4 (1921).
[2] J. B. Trimble, Jr., *Eng. Min. Jour.*, 111, 1079 (1921).
[3] A. B. Parsons, *Min. Sci. Press*, 123, 775 (1921).

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the open circumferential ends are above the surface of the pulp and thus scoop in some air which by the revolution of the rotor is carried into the pulp and worked inward toward the center of the rotor and finally discharged at the shaft sidewise into the diffusion member. This latter consists of a series of three concentric hollow cylinders perforated with square holes and having solid ends. The pulp thus works outward through the diffusion member and is thoroughly beaten up and aerated. It then overflows into the spitzkasten and the bottom of the spitzkasten connects back into the frothing chamber. The adjustable inlet valve serves to regulate the amount of air admitted to the pulp, a feature not possessed by any other machine so far as the authors are aware. The frothing cells are 24 in. square and 3, 4 or 5 cells are incorporated in one machine requiring less than 0.5 hp. per cell.

The Ruth flotation machine, manufactured by the Denver Engineering Works, is finding considerable application in Colorado, especially in small plants to work over old dumps.

The Gröndal flotation machine used in Germany[1] is practically a Minerals Separation subaeration cell. The consumption of compressed air is between 0.6 and 1 cu. m. per min. for each unit and the total power consumption is about 6 hp.-hr. per machine.

Oils and Reagents.—Several patents on the use of organic flotation agents have been taken out. Excellent results have been obtained by the use of Ketone condensation products as flotation agents in as small amount as 2 to 3 oz. per ton of ore.[2] Patents have also been taken out by C. L. Perkins and R. E. Sayre (U. S. Pat. No. 1,370,357) on terpin hydrate and by R. E. Sayre (U. S. Pat. Nos. 1,370,366 and 1,370,367) on dihydric alcohols and the reaction product of hydrogen sulphide on acetaldehyde or other thioaldehyde compounds. Only very small amounts of these reagents are necessary. Other patents are Nos. 1,364,858, 1,364,859, 1,364,304–8, 1,356,832, and 1,378,562.

Instead of alpha naphthylamine and xylidin, the use of thiocarbanalid dissolved in orthotolindine has been found to give equally good results and to be cheaper.

The Luckenbach process, which has been promoted for some years, but which has never had much application, is no longer a secret process, as a recent patent shows that it relies upon "Rex" flotation agent, which is colloidal pitch in alkaline solution.[3]

The presence of ammonia water has been found to be bad for flotation

[1] *Eng. Min. Jour.*, **112**, 215 (1921).
[2] R. Sayre, U. S. Pat. No. 1,370,843.
[3] *Eng. Min. Jour.*, **112**, 239 (1921); *Can. Min. Jour.*, **42**, 616 (1921); *Min. Sci. Press*, **123**, 175 (1921).

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in some cases, so that where crude tar is employed as a flotation agent it is advisable to free it from ammonia.

An investigation of Western wood oils, their extraction and application for flotation purposes, has shown that they all have good frothing properties and some are the equivalent of pine oil.[1]

Considerable study has been made of oils and reagents at the Engels Copper mill, California.[2] Sodium hydroxide formerly was used as a flotation reagent. It stiffened the froth and improved the extraction, but lowered the grade of concentrates. The oils now used are: (A) Diesel oil, 24° B. fuel oil from the Standard Oil Co.; (B) No. 14 crude pine oil high in turpentine; (C) No. 7 fuel oil, standard grade; and (D) kerosene oil. These are made into mixtures as follows:

	No. 1.	No. 2.	No. 3.
	Per Cent.	Per Cent.	Per Cent.
A	.....	85	40
B	15	15	35
C	75	.....	25
D	10	.....	.....

The froth that formed when using a mixture of B and C was tough, but the grade of concentrate was low. A and B gave a clean concentrate, but if the proportion of oil fell below the ideal amount the froth would not carry the sulphides and a high tailing resulted. On the other hand, an excess of oil could be used without making a noticeable difference in the appearance of the froth, thereby causing waste of oil. For these reasons the fuel oil is added to the mixtures.

No. 1 mixture is added at the head of the Marcy mill; No. 2 and No. 3 at the tube-mills, or, if necessary, in the first compartment of the flotation machine. Control of the oil-feed is centralized at one point near the machines so that the operator can make adjustments easily and quickly. It is desirable to add as much as possible of the required oil before the Minerals Separation machines are reached, as raw oil kills the froth. The practice is to keep safely on the "low" side in the mill and to make up any deficiency by adding some of the mixture richest in frothing oil in the cells. This scheme of proportioning and adding the oils is unusually complicated, but the good results seem to answer any criticism.

[1] J. W. Cook, Henry Schmitz and L. A. Grant, *Univ. Idaho Bull.*, **16**, No. 13 (1921).
[2] A. B. Parsons, *Min. Sci. Press*, **123**, 183 (1921).

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During the month of March, 1921, the amounts of the various oils used were as follows:

	Amount Used Per Ton of Ore Milled, Per Cent.	Proportion of Total, Per Cent.
A	0.5945	51.91
B	0.2895	25.28
C	0.2443	21.33
D	0.0170	1.48

For floating chalcopyrite from pyrite at one plant success was obtained by using soluble frothing agents that required no agitation and diffused in the water of the pulp without any stirring whatever.[1] The ore containing 2 to 2.5 per cent. copper was crushed so that 85 per cent. passed 200 mesh and was floated in pneumatic cells with a mixture of alphonaphthylamine and xylidine. A distinct selective separation of the chalcopyrite as against the pyrite was effected, the concentrate assaying from 11 to 13 per cent. copper and containing 90 per cent. of the total copper of the ore.

The latest form of the General Engineering Co. Oil and Reagent Feeder has the usual wheels in separate compartments with the adjustable take-off scrapers, but the whole thing is self-contained, being driven by an individual motor through worm and gear.

Handling Flotation Concentrates.—Water jets to break down the froth, followed by Dorr thickeners or settling tanks, and drum filters are now almost universally used. At the Smuggler Union mill, Dorr Bowl classifiers are used to divide the flotation concentrate into a coarse product and slime. The latter is thickened in a Dorr thickener and filtered in a Portland filter. The filter-cake and coarse product are united and sent to a drying bin.

A device for breaking down flotation froth developed and used at the mill of the Cia. Corocoro de Bolivia consists of a fan 4 ft. in diameter with blades 6 in. wide run at 250 r.p.m. The suction produced at the entry at the center of the fan kills the froth, which goes out as a liquid at the periphery entirely without foam. The machine is 2 ft. high, uses very little power, and has a capacity of over 50 tons of froth in 24 hr.[2]

A modification of the Dorr thickener has been patented by P. A. MacEachern and L. D. McRae, and is used by the Moctezuma Copper Co. and the Potter and Palmer Co. at Nacozari, Mexico.[3] The Dorr tank has attached to its vertical shaft an inner bottomless tank, or dia-

[1] A. B. Parsons, *Min. Sci. Press*, **122**, 775 (1921).
[2] F. A. Sundt, *Eng. Min. Jour.*, **112**, 983 (1921).
[3] G. L. Schmuts, *Eng. Min. Jour.*, **111**, 18 (1921).

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phragm, and skimmer arms, which revolve with the shaft. The feed is introduced at the top of the diaphragm, and the outer tank is charged from the bottom of the diaphragm, which is about one-third the diameter of the outer tank and which extends downward about two-thirds of the depth of the outer tank. An annular stationary ring protects the clear-water overflow from froth and skimmers discharge the froth into a launder. Clear water, froth, and thickened concentrates are the products made.

W. C. Clark[1] gives some costs of drying fine flotation concentrates. At the plant of the Hayes Milling Co. a 5 by 17-ft. Lowden drier of the grasshopper type, oil heated, delivered an average of 175 tons of dry product per month at an oil cost of $6.90 per ton of water removed. The feed carried 35 per cent. and the product about 15 per cent. water.

At the Gold Hunter mill an electric drier installed on top of an Oliver filter consists of eight coils of high-resistance wire wound on 1-in. iron-pipe supports and placed 1 ft. apart across the face of the filter. A total input of about 31.6 kw. is consumed. The drier is heavily insulated with asbestos to prevent radiation. The moisture content of the concentrates has been reduced from 11 to 8.7 per cent. at a current cost of $6.86 per ton of water extracted.

At the Bunker Hill and Sullivan experiments have been made with an iron pipe 12 in. in diameter and 10 ft. long, set horizontal for rotating. Asbestos is wrapped about the pipe to a thickness of ⅜ in. and over the asbestos is wound 90 lb. of No. 4 bare hard-drawn copper wire, giving 205 turns. Collector rings deliver 82 amp. at 282 volts to the winding while the pipe is turning at 7 r.p.m. The heat is generated by eddy currents or hysteresis in the shell of the pipe and is prevented from radiating by asbestos. A rabble system moves the material from one end of the pipe to the other. The concentrates fed to the drier contain 11.4 per cent. moisture and are dried to 6 per cent. at a capacity of about 17 tons per 24 hr. and at a cost of $5.66 per ton of water removed.

Testing.—Methods and equipment for testing ores by flotation have been given by A. W. Fahrenwald.[2]

Theory.—As in past years various authors have expressed their ideas as to the causes of flotation.

F. G. Moses and A. W. Fahrenwald[3] have discussed the functions of agitation in flotation as regards (1) mixing of oils or reagents in the pulp, (2) the production of the air necessary for froth flotation, and (3) as a means of increasing the circulation of the pulp in the flotation apparatus.

F. G. Moses has given an elementary explanation of some of the more

[1] *Eng. Min. Jour.*, 111, 909 (1921).
[2] *Idaho State Bur. Mines Pamphlet*, No. 3 (1921).
[3] *Min. Sci. Press*, 123, 477, 699 (1921).

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important physical principles underlying the phenomena of surface energies.[1]

J. Traube[2] has discussed the theory of flotation along the lines of surface tension, colloidal action, adsorption, sedimentation, and electric charges.

R. S. Dean has outlined the theory of flotation to constitute a usable working hypothesis and states the necessary condition for flotation according to that theory.[3]

Interfacial tension measurements with some applications to flotation have been made by R. S. Elder[4] and the size of mineral particle in its relation to flotation concentration has been discussed by A. W. Fahrenwald,[5] who has also in two papers dealt with differential flotation theory, including phenomena of interfacial tension and adsorption and effect of contaminants and colloids.[6]

B. H. McLeod[7] has presented an interesting fact for the theorists to consider. He took some flotation concentrates floated in a neutral circuit and found that when the slimy portions were removed from these concentrates, acid was required in order to refloat them, but if the slimes were restored the acid was not necessary in refloating them.

Litigation.—During 1921 several new infringement suits were instituted in the flotation litigation, through the filing, in February, of bills of complaint by Minerals Separation and its associated Minerals Separation North American Corporation against the Utah Copper Co., Ray Consolidated Copper Co., and Chino Copper Co., and a second suit against the Nevada Consolidated Co. was also brought. Suit was also brought against J. M. Callow and the General Engineering Co. None of these suits which were brought in 1921 reached a hearing in court during the year.

In the Butte and Superior case a motion of an unusual nature was argued before Judge Bourquin, in the U. S. District Court, sitting at Helena, Mont., July 21, 1921. It was sought in this motion to have the Court instruct the Master (L. P. Donovan) who had been appointed in the Butte & Superior accounting as to what should constitute a standard of comparison for determining the amount of profits for which Butte & Superior could be held responsible. In the Butte & Superior case before the Supreme Court, Minerals Separation was not sustained in its contention that the process which the Butte & Superior company had used, with an amount of oil in excess of 1 per cent. upon the ore, was an

[1] *Eng. Min. Jour.*, **111**, 7 (1921).
[2] *Metall u. Erz*, **18**, 405 (1921). *Zeit. Ver. Deut. Ing.*, **65**, 654 (1921).
[3] *Min. Sci. Press*, **122**, 291 (1921).
[4] *Idaho State Bur. Mines Pamphlet*, No. 1 (1921).
[5] *Idaho State Bur. Mines Pamphlet*, No. 2 (1921).
[6] *Idaho State Bur. Mines Pamphlet*, No. 4 (1921). *Min. Sci. Press*, **123**, 227, 498, 631 (1921).
[7] *Eng. Min. Jour.*, **112**, 213 (1921).

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infringement. Minerals Separation had contended that petroleum was not "a frothing oil" upon the defendants' ore; the Supreme Court declared, however, that patent No. 835,120 made no distinction as to "frothing oils," and the Supreme Court therefore held the plus 1-per cent. process not to be infringing. This motion, before Judge Bourquin, had as its announced object the preventing of the undue extending of the time consumed in the accounting proceedings beyond proper limits; the defendant, however, saw in the motion an attempt upon the part of Minerals Separation to confine Butte & Superior to water-gravity concentration as the standard of comparison. The Minerals Separation contended that the only process, or processes, available, as standards of comparison, were such as were known and available for use, at the time of the *invention*, whereas, upon the other hand, Butte & Superior contended that the standard of comparison could be any process known and open to them at the time of the *infringement*. Judge Bourquin in his opinion, rendered Aug. 12, 1921, seems clearly to have sustained the Butte & Superior company's position, since he said: "The rule of comparison is settled law, and contemplates that the infringer had a choice of processes, chose that of the patent, and gained an advantage over what would have been his had he chosen otherwise. Obviously his choice is made from the processes existing at the time of the choice, that is at the time of the infringement, as from day to day an alternative presents itself. He is not limited in fact to the process of the patent and processes existing only at the date of the patent, and the principle of standards does not require nor sanction that he be so limited in theory."

The hearing before the Master in the Butte & Superior case was set to be held in New York City, Oct. 31, 1921, but was held Nov. 3 to 9. As the result of this hearing it transpired that Minerals Separation presented a claim for $11,904,913.95 as representing profits and gains and advantages which the Butte and Superior company had realized from the use of the Minerals Separation process, the magnitude of this amount being due to the setting-up of water-gravity concentration as the standard of comparison. This hearing was adjourned to meet Feb. 14, 1922.[1]

In the Miami Copper Co. case the hearings before the Master (the taking of testimony before whom commenced in April, 1918) continued

[1] On Apr. 28, 1922, negotiations which had been in progress for some weeks, between Minerals Separation, Ltd., upon one hand and the Jackling companies, including Butte & Superior, and also in addition Miami Copper Co. upon the other hand, arrived at a compromise. No complete detail of the terms of the compromise has as yet been given for publication. Approximate figures have appeared in the daily and financial press, as well as the mining press. The figures there given should be for the Jackling companies, including Butte & Superior, $3,500,000 and for Miami $850,000. This is a lump sum.

By this compromise, naturally, much that was of vital interest in the procedure is now largely of academic interest. It leaves, unfortunately, the question as to legal difference between the agitation and bubble-column processes without hope of any immediate adjudication. The last of the patents involved in the compromise will expire in 1927.

It will be noted that the Magma and Callow suits are not included in this settlement.

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with regularity throughout the year 1921 until Nov. 1, when the Minerals Separation *prima facie* case before the Master closed, after four years consumed in examination and cross-examination of Minerals Separation witnesses, largely as to operations subsequent to those which had been found by the court to have been of an infringing nature.

In addition to the taking of testimony before the master, the Miami case was before the court in relation to an application, upon the part of Minerals Separation, for a supplementary bill seeking to make Minerals Separation North American Corporation party to the suit, and also, upon the part of Miami Copper Co. in an appeal from the Master's ruling denying the contention of the defendant that the master should exclude from his consideration all reference to the so-called subsequent acts of infringement. This contention was based upon the decision of the U. S. Court of Appeals in 1920 confirming Judge Morris in his ruling in which he failed to find the Miami Copper Co. in contempt of court for its continued use of its form of flotation process.

As to the first of these, the application by Minerals Separation for supplemental bill having as its object the making of Minerals Separation North American Corporation party to the suit, testimony was heard in Wilmington, Del., Jan. 17, 1921; the arguments were made Apr. 2, and Judge Morris' decision granting the petition was rendered July 15. Had this decision found, as Miami Copper Co. claimed, that upon July 8, 1913, Minerals Separation had actually transferred its legal interest in its patents to the Minerals Separation North American Corporation, the effect would have been very far reaching, even to the possibility of throwing out of court the Miami suit, and other suits brought by Minerals Separation alone as plaintiff. The court found, however, that the transaction of July 8, 1913, had not constituted the transfer of Minerals Separation's legal title.

And as to the appeal to the Court from the ruling of the Master, in which the master decided against the contention of the Miami Co. that he should exclude from his consideration all reference to the so-called subsequent acts of infringement, no precedent was found in support of the plaintiff's contention, nor indeed of any similar situation, so that both the lower court and the Court of Appeals sustained the Master's ruling, without, however, in any way modifying the very persuasive language which the Court of Appeals had used in its opinion failing to find the Miami company in contempt of court for the continued use of its form of the flotation process, *i.e.*, the bubble-column process.

The subject of flotation litigation to date has been comprehensively reviewed by T. A. Rickard.[1]

[1] *Min. Sci. Press*, **122**, 115, 119 (1921).

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Operation and Details of Practice.—Flotation practice in some of the new mills will be found described later under *Examples of Practice*, and flotation of coal is considered under *Coal Washing*.

A complete story of the development and present operations on Catému copper ores has been given by F. Benitez.[1]

New books on flotation are "Concentration by Flotation," by T. A. Rickard (John Wiley & Sons, Inc., 1921) and "A Manual of Flotation Processes," by Arthur F. Taggart (John Wiley & Sons, Inc., 1921).

Accessory Apparatus

The tendency to replace dry bucket-elevators by inclined conveyor-belts still continues. The remodeled Miami coarse-crushing plant does away entirely with bucket-elevators. The Nevada Consolidated mill has followed suit. At the Chino mill the air-lift plant, which was installed instead of bucket-elevators, has been in operation for two years. Its construction and operation have been described by H. G. S. Anderson,[2] who shows figures indicating that the cost by air-lift method is only one-half that by bucket-elevator.

In an article on the use of rubber in the mine and mill, A. M. Oliver[3] has dealt with the construction, operation, life and wear of rubber belting for belt-elevators and conveyors.

Rubber-lined and rubber-covered impeller pumps have been developed by the Allis Chalmers Co. and the Byron Jackson Co. It is believed that these will be revolutionary in the handling of sand tailings and fairly granular mill products.

For chute linings in the Calaveras flotation mill, worn-out ball-mill liners are cut to size by acetylene torch and laid in the bottom of the chute.[4]

Launders are even being built of concrete where long life and minimum cost of upkeep are desired. They do not lend themselves to changes in mill arrangement.

The Dresser-Youtsey sampling device which is used very satisfactorily in the mill of the St. Louis Smelting and Refining Co. at St. Francois, Mo., possesses the merits of simplicity, accuracy, and freedom from wear and breakdown. Briefly, an electric motor drives a vertical threaded shaft carrying a threaded nut which is moved up or down, as the case may be. When the nut reaches a predetermined point either way in its travel it engages a lug on a sleeve which is loose on the shaft, and the sleeve is thus revolved and by means of pulley-and-belt connection moves

[1] *Min. Sci. Press*, **123**, 921 (1921).
[2] *Eng. Min. Jour.*, **112**, 806 (1921).
[3] *Eng. Min. Jour.*, **111**, 258 (1921).
[4] *Eng. Min. Jour.*, **112**, 20 (1921).

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the sample cutter through the stream of pulp and at the same time operates a rack-and-pinion gear which throws a reversing switch on the motor. With the motor reversed the threaded nut travels in the opposite direction until it reaches another sleeve and lug on the other end, when the cutting of a sample and reversal of the motor again occurs.

In the Auto sampler of the Galagher company a pulley operates a slow-motion ratchet wheel on a shaft which has a cam which raises two weight-arms alternately and then lets them drop. When one drops it operates a lever which swings the cutter through the pulp stream; when the other drops it swings the cutter back again.

. In a symposium on drying at the meeting of the American Chemical Society in April, 1921, R. G. Merz contributed a paper on direct-heat rotary driers.[1]

At the sixty-second meeting of the American Chemical Society in September, 1921, various authors contributed papers on methods and apparatus used in commercial filtering.[2]

Principles, Theory and General, Ideas

Two very important notes have been sounded to call attention to possibilities of improvements and increased efficiencies. The one by E. A. Wright[3] is on the subject of standardization of materials employed in milling, and the other by H. A. White[4] is on the correlation of metallurgical statistics.

Although standardization is in use for the materials employed in general engineering practice, particularly in the automobile trade and aviation, little has been accomplished in milling materials. Wright has presented data on various materials proving both the lack of uniformity in materials supposedly the same and the extreme confusion existing as to the relative merit of different materials for any particular use. He emphasizes the necessity for the collection of reliable data and the whole-hearted assistance of manufacturers and mill managers. The data presented form a start on the following: stamp-battery components, rolls, balls for mills, rock-breaker jaws, tube-mill liners. Considerable discussion has followed. The subject is a vital one in the improvement of efficiency and should receive a merited increased attention.

In the mass of data collected and filed or thrown away in mining and milling operations are locked many valuable conclusions because the individual facts have not been correlated and compared to a sufficient

[1] *Jour. Ind. Eng. Chem.*, **13**, 449 (1921).
[2] *Jour. Ind. Eng. Chem.*, **13**, 976–1007 (1921).
[3] *Bull. Inst. Min. Met.*, No. 196 (1921). *Min. Jour.*, **132**, 107, 124, 146, 167 (1921). *Min. Sci. Press*, **122**, 361, 739 (1921). *Mining Mag.*, **24**, 67 (1921). *Eng. Min. Jour.*, **111**, 293 (1921).
[4] *Jour. Chem. Met. Min. Soc. So. Afr.*, **22**, 97 (1921).

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degree. White has demonstrated the value of an application of modern statistical mehods to ore-dressing operations. He gives a brief resumé of the principles involved and illustrates their application to a sorting and crushing problem in detail.

An extremely interesting case of benefit to concentration in increasing cyanide plant capacity is reported by C. Flury.[1] The number of stamps had been increased and no increase in the size of the hydrometallurgical equipment was permissible. It was decided to try for increased capacity by concentrating the stamp-mill product before cyanidation. The sand was concentrated in a ratio of 4 to 1 by means of Wilfley tables after preliminary classification of the pulp into sand and slime. An extraction of 90.2 per cent. was realized with concentration as against 80 per cent. previously obtained by direct treatment of sand. A saving of one-half of the zinc and lime was also effected. This very favorable increase is attributed to three main facts: (1) The total treatment was prolonged from 12 to 25 days; (2) the tailing assay remained nearly constant no matter what the grade of material treated, so that high-grade concentrate provided a higher extraction; (3) during the passage of the sand over the tables, most of the water-soluble salts were washed out.

In an article on preliminary roughing concentration by sorting, jigging and tabling, E. S. Wiard[2] has discussed the principles of the art and has taken up hand sorting, its limits and how it may be improved; the practical application of jigs and the adaptability of different types; a diagram presenting the principles underlying the separation in jigs of grains of various sizes and specific gravities; automatic discharge devices and their inherent defects; experiments with a test jig; the Wilfley table as a rougher; and the use of deflectors and baffles on tables. The principles on which the jig operates are fully analyzed and the possible more extensive use of jigs in roughing pointed out. Experiments are also described whose results indicate possible improvements in jig construction.

A general article giving mathematical theory, principles of machines, and typical flow-sheets has appeared from the pen of A. Lhéraud.[3]

One is struck with the increased use of concrete, not only in the mill structure itself, but in individual apparatus such as bins, launders, pulp-storage and settling tanks, and other parts of concentrating machines. Rectangular concrete tanks are a part of the equipment of the New States Areas gold mill in South Africa, for collecting slime and storing pulp and solution. Their use is based on the advantage of lower first cost and maintenance as compared with wood.

[1] *Min. Sci. Press*, **123**, 768, 771 (1921).
[2] *Eng. Min. Jour.*, **112**, 326, 369, 411 (1921).
[3] *Rev. Ind. Minerale Memoirs*, **1**, 371 (1921). *Genie Civil*, **79**, 106 (1921).

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Examples of Practice

Not many new mills were built in 1921, but some of those that were constructed were first-class, representing the very latest practice in mill design. They are marked by simple flow-sheets, rugged and permanent construction, and fool-proof apparatus.

An enumeration of eight new flotation plants includes the Nevada Consolidated mill for copper, the Copper Queen mill for copper, the Utah Consolidated mill for copper, the Smuggler Union mill for lead, silver, gold, copper and zinc, the Boston and Montana mill for silver and copper, the Simon Silver-Lead mill for lead, silver and zinc, the California Rand Silver mill for silver and gold, and the Cerro Gordo mill for lead and silver. These mills have all been described and compared in detail by A. B. Parsons.[1]

The new Santa Barbara mill[2] in Chihuahua, Mexico, is designed to treat carbonate lead ores beside old mine and tailings dumps. The ore averages 60 per cent. silica, 7 lime, 9 iron, and 3 per cent. sulphur. The flow-sheet is as follows, all tonnages being expressed per 24 hours in the metric system.

(1) Railroad cars dumping into 500-ton receiving bins. By 24-in. belt-conveyor, to (2).

(2) Grizzly, 1½-in. spaces. Oversize to (3); undersize to (4).

(3) No. 5 McCully gyratory breaker, to 1½ in. By 24-in. belt-conveyor with magnetic head pulley, to (4).

(4) Fixed plate screen, 40° slope, 1⅝-in. holes. Oversize to (5); undersize to (6).

(5) Symons horizontal disc crusher, 48-in., crushing to ½ in. To (6).

(6) Belt-conveyor, 18-in., to 500-ton fine ore bin and thence by 24-in. belt-conveyor feeder, to (7).

(7) Two trommels, 48 by 72 in. with ½-in. holes. Oversize, 200 tons, to (8); undersize, 300 tons, to (10).

(8) Two shovel-wheel unwaterers. Sand to (9); overflow to (10).

(9) Two Cole-Bergman rod-mills, 5 by 10 ft., 19.8 r.p.m., grinding to 50 per cent. through 2 mm. To (10).

(10) Eight Cole oscillating screens, 3 by 4 ft., 2-mm. holes. Feed, 1170 tons. Oversize, 645 tons, to (11); undersize, 525 tons, by two 18-in. belt-elevators, to (12).

(11) Two 14-in. belt-elevators, handling 670 tons, to (8).

(12) Dorr duplex classifier, type D. Sands, 425 tons, to (13); slimes, 100 tons, to (17).

(13) Two 8-spigot Deister cone classifiers. Spigots 1 and 2, 176 tons, by mechanical splitter to eight tables in (14); 3 and 4, 74 tons to 4 tables; 5 and 6, 65 tons to 4 tables; and 7 and 8, 50 tons to 4 tables; overflow, 60 tons, to (17).

(14) Twenty Deister sand tables. Concentrates, 40 tons, to (19); middlings, 40 tons, by 18-in. belt-elevator, to (15); tailings, 285 tons, by two 18-in. belt-elevators, to (16).

[1] *Min. Sci. Press*, **122**, 775 (1921).
[2] F. M. Heidelberg, *Eng. Min. Jour.*, **112**, 1050 (1921).

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(15) Four Deister clean-up tables. Concentrates, 15 tons, to (19); tailings by centrifugal pump, to (11).

(16) One Dorr duplex classifier, Class C. Sands, 265 tons, to dump for possible future treatment; overflow, 20 tons, to (17).

(17) Two 50-ft. Dorr thickeners 10 ft. deep. Feed, 180 tons. Underflow, 180 tons, by two 14-in. belt-elevators and mechanical distributors, to (18).

(18) Sixteen Deister slime tables. Concentrates, 12 tons, to (19); tailings, 168 tons, to (21).

(19) One 18-in. elevator, to (20).

(20) Seven concrete tanks for dewatering and filtering 67 tons of concentrates, each 12 by 36 ft. and 4.5 ft. deep.

(21) One 50-ft. Dorr thickener. Thickened slime goes to experimental flotation plant where a filming process is being worked out.

The water required for this mill is 6929 metric tons per 24 hr., of which 6327 metric tons is recovered. No results of mill work have been reported as yet.

The new Copper Queen mill at Bisbee[1] is designed to treat porphyry copper ore from Sacramento Hill. It has four units of 1000 tons capacity each. The ore is brought in railroad cars to (1).

(1) Grizzly. Oversize to (2); undersize to (3).

(2) Blake jaw-breaker, 66 by 84 in., crushing to 8 in. To (3).

(3) Two 4-in. pan-conveyors to 500-ton surge bin and thence by two 48-in. belt-conveyors, to (4). Smelting or leaching ore may be diverted from the surge bin.

(4) Two revolving grizzlies. Oversize to (5); undersize to (6).

(5) Two No. 9 Gates gyratory breakers, crushing to 4 in. To (6).

(6) Two 36-in. belt-conveyors. To (7).

(7) Two trommels with 2-in. holes. Oversize to (8); undersize to (9).

(8) Four 48-in. Symons disc crushers, crushing to 1½ in. To (9).

(9) One 42-in. inclined belt-conveyor, followed by a second 42-in. conveyor and a distributing conveyor to 10,000-ton bins. From this point on only one of the four units is given. Crushed ore by six 20-in. apron feeders and a series of 24-in. belt-conveyors, to (10).

(10) Two 6.5 by 12-ft. Marcy roller mills with 18 tons of 3-in. rods, 17.5 r.p.m. Product, 14 mesh, to (11).

(11) Dorr classifier. Sands to (12); slimes to (16).

(12) Ten Plat-O tables for roughing. Concentrates by air-lift to shipping bins, where water is drained off and repumped to (19); tailings to (13).

(13) Two 4.5 by 18-ft. Dorr classifiers for dewatering. Sand to (14); slime to (15).

(14) Two mills like (10). To (15).

(15) Two Dorr duplex classifiers. Sands to (14); slime to (16).

(16) Two Callow flotation machines of the Inspiration type with 22 cells each. Concentrates, by air-lift, to (17); tailings to (18).

(17) Two Callow machines like (16), but six cells each. Concentrates to (19); tailings to (16).

(18) Twenty Plat-O tables. Concentrates to (19); tailings to (20).

[1] J. B. Trimble, Jr., *Eng. Min. Jour.*, 111, 1079 (1921).

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(19) Six 75-ft. Dorr thickeners followed by two bucket-elevators for the underflow to five 14 by 14-ft. Oliver filters. Clear water from thickeners and filters is used again.

(20) Dorr tank for tailings, 200 ft. in diameter. Underflow to waste; overflow back to mill.

The mill requires 1516 gal. of water per ton treated, and of this 376 gal. is fresh water and 1140 gal. is repumped.

The remodeled coarse-crushing plant of the Nevada Consolidated mill is as follows:

(1) Train from mine, over automatic track-scales, to (2).

(2) Horizontal grizzly with 18-in. spaces. Oversize broken by hand and dynamite to pass openings; undersize to (3).

(3) Coarse-ore bin, 5000 tons. By 24 apron-feeders and pan-conveyors, to (4).

(4) Traveling grizzly with 3.5 by 60-in. slots. Oversize to (5); undersize to (6).

(5) No. 8 McCully breaker, to 3½ in. To (6).

(6) Inclined belt-conveyor with 19° 20′ slopes. To (7).

(7) Mitchell vibrating screens, 6 mesh. Oversize to (8); undersize to (11).

(8) Coarse rolls. To (9).

(9) Mitchell screens, 6 mesh. Oversize to (10); undersize to (11).

(10) Fine rolls. To (11).

(11) Inclined belt-conveyor, 16°. To fine-ore bins, 30,000 tons capacity.

From the fine-ore bins the ore passes to the different sections of the mill, which vary somewhat. No. 3 section uses the Inspiration principle of flotation followed by tables. No. 4 introduces the Garfield roughing-table system. Briefly the flow-sheet of No. 3 is as follows:

(1) Pulley feeder, 500 tons per day. To (2).

(2) Hardinge ball-mill, 30 in. by 8 ft., in closed circuit with 6-ft. Dorr duplex classifier. Classifier overflow, through chip screen, to (3).

(3) Callow rougher flotation cells, 30 in. wide, 20 ft. long, bottom sloping ½ in. per ft. Concentrates to (4); tailings to (5).

(4) Callow cleaner cells. Concentrates to (6); tailings to (5).

(5) Wilfley tables. Concentrates to (6); tailings to (7).

(6) Dorr thickeners, 60 ft. in diameter, followed by Oliver and Portland filters. Cake with 15 per cent. moisture, to smelter. Water returned to Dorr classifier (2).

(7) Dorr thickener. Underflow to waste; overflow pumped back as wash-water for mill.

In the No. 4 section the ore is fed first to the Garfield roughing table and the concentrates are cleaned on a Wilfley table which makes final concentrates. The tailings from both the Garfield and Wilfley table go to Dorr classifier coupled with Marcy ball-mill instead of Hardinge mills as in section No. 3. From this point on the treatment is exactly the same as in No. 3 section.

The ore is a copper porphyry assaying 1.5 per cent. copper, of which 0.10 per cent. is oxide copper. Extraction is 81.6 per cent.; tailings assay 0.306 per cent. and the concentrates assay 12.59 per cent. copper,

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27.3 per cent. insoluble, and 23.5 per cent. iron. The ratio of concentration is 10.3:1.

The history of this mill with its flow-sheets and details at various periods has been given by A. B. Parsons.[1]

The Engels copper mill in Plumas County, California, is an example of a recently built plant using straight flotation. It has been fully described by A. B. Parsons.[2] Crushing and grinding is carried to the point where 90 per cent. of the product will pass 100 mesh. This involves 5 steps: No. 3 Traylor gyratory breakers to 3 in.; No. 5 McCully gyratories to about 1.5 or 2 in.; 24- by 54-in. rolls to 1 in.; Marcy and Hardinge mills for coarse grinding; tube-mills for fine grinding. The concentrating equipment consists of two Minerals Separation machines followed by 15 Callow roughers and Callow cleaners. The arrangement varies from time to time, but in a general way the Minerals Separation machines make a finished concentrate and three other products which are worked back and forth in the Callow cells until clean concentrates are finally obtained from two cells and clean tailings from two other cells.

The mill has a capacity of 1000 tons per day. The minerals are mainly bornite and chalcopyrite finely disseminated in an altered diorite gangue. The ore assays 2.21 per cent. copper, about 0.5 oz. silver per ton and a little gold. The concentrates assay 29.76 per cent. copper, 8.3 oz. silver and 0.08 oz. gold, while tailings assay 0.45 per cent. copper. Extraction figures out 80.93 per cent.

The Boston and Montana 600-ton mill for copper-silver ore treats the ore in a No. 6 Telsmith gyratory breaker and grinds it to table size in an 8- by 4-ft. Hardinge mill in closed circuit with Dorr duplex classifier. The ground product is elevated to eight roughing James tables, which make concentrates going to four cleaning James tables, which make a lead concentrate, a copper concentrate, a middling returned to the roughing tables, and a tailing. Tailings from both sets of tables are reground in a 7- by 3-ft. Hardinge mill in closed circuit with Dorr duplex classifier, then thickened in a 40-ft. Dorr thickener and floated in six Janney cells for roughing followed by two Janney cells for cleaning the concentrates from the roughers. Tailings from the roughers are waste; those from the cleaners go back to the roughers. Concentrates from the cleaners, together with the copper concentrates from the tables, are thickened in two 50-ft. Dorr thickeners and filtered in an Oliver filter.

The remodeled Cananea flow-sheet has the following operations: (1) 3-in. grizzly; (2) gyratory breaker; (3) magnet and magnetic head-pulley; (4) Cole screen, 1 in.; (5) 48-in. Symons disc crushers to 1 in.; (6) fine-ore bins, 2800 tons capacity; (7) Cole rod-mills, 6 by 12 ft.; (8) Hardinge

[1] *Min. Sci. Press*, **123**, 323 (1921).

[2] *Min. Sci. Press*, **123**, 183 (1921).

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mills, in closed circuit with drag classifiers, to 48 mesh; (9) Cole-Bergman flotation machines; (10) Dorr thickener and Oliver filter for concentrates; (11) Wilfley tables which may possibly be used on tailings.

This is a much simpler plant than the old mill, which had jigs, tables, and flotation and saved all the sulphides including barren pyrite. On the two ores, Cananea Duluth with 7 to 10 per cent. iron and the Capote 15 with 15 to 17 per cent. iron, the concentration ratios with the old plant were respectively 4 and 3 into 1. It is expected that the new mill will bring these up to 6½ or 7 and 4 or 4½ respectively, with no increased loss in recovery. If lime is used as a reagent on the Capote 15 the concentration ratio can be raised to 8 or 8½ to 1 with a sacrifice of 2 per cent. of the total copper recovered. The new mill should use less labor, less power, and less water and have less operating cost including repairs.

The discarding of jigs in the Bonne Terre lead mill, reported last year in MINERAL INDUSTRY, has proved to be a wise step, as the best recovery ever recorded in the history of the plant is being obtained with a tailing assay of 0.35 per cent. lead. No other mills in the district have discarded jigs and introduced finer crushing, and it is a question whether they will do so since they could not expect to make so much of a gain as the Bonne Terre mill on its more finely disseminated ore. The introduction of mechanical shoveling underground has necessitated a larger breaker in the Bonne Terre mill to handle the coarser material.

The Alaska Juneau mill [1] is gradually ironing out its difficulties and making adjustments of crushers, grizzlies, and screens so as to increase the efficiency of the hand sorting and lessen the proportionate amount of ore actually milled. The present capacity is 7000 tons per day, with at least 60 per cent. rejected as coarse tailings, and at an indicated cost of 17.5 cts. for mining, 20.5 cts. for milling, and 2 cts. for all else, or a total of 40 cts. per ton mined. The report for 1921 shows 1,613,600 tons mined, of which 709,297 tons was rejected as coarse waste. The total costs were 58.40 cts. per ton mined, of which 19.97 cts. was for mining, 35.53 cts. for milling, and 2.90 cts. for other miscellaneous expense. The history of the Alaska Juneau enterprise with an enumeration of the difficulties and defects which have been overcome and a description of the present practice has been given by V. C. Clauson.[2]

High loses in milling Wisconsin zinc ores, which have amounted to as high as 50 per cent. of the metal taking the entire milling and metallurgical processes, are in part due to local condition and the very short life of the mines, and in part due to the presence of marcasite which cannot be easily removed from table concentrates by roasting and magnets. Consequently jigs have been the only gravity machines that have been

[1] See MINERAL INDUSTRY, 29, 792 (1920).

[2] *Min. Sci. Press*, 122, 623, 629 (1921).

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employed in these mills and even these have not been run to the best advantage. D. I. Hayes[1] has shown how the jig work has been much improved by entire rearrangement of the jigging system by careful regulation of the jig adjustments, and by elimination of surplus water. The U. S. Bureau of Mines has gone further than this and demonstrated that by making rough table concentrates at each plant the fine zinc which now goes to waste can be saved in a low-grade lead-zinc-iron product which can be profitably treated at a central flotation plant, where the reground ore can be selectively floated in an acid solution using sodium dichromate to deaden the lead and iron and obtain a high-grade zinc product. This entirely eliminates the roasting and magnetic work. It is possible to recover the lead by tabling the flotation residue. It is even proposed that jig concentrates can be handled more profitably by this method than by the present roasting and magnet. Pine-oil reagents give the best flotation results in this work.

Messrs. Coghill and Anderson of the U. S. Bureau of Mines have likewise made a thorough study of the milling methods of the Joplin district. They have reached the conclusion that there is a lot of clean gangue reground with the middlings and that the fundamental weakness lies in the imperfect devices for removing the middling products. Their suggestions are that the mill scheme be revised so that the ore first passes over a jig which takes out the clean lead and zinc as a high-grade concentrate, and passes the tailings, after dewatering and sizing, to a second jig which is so adjusted as to separate middlings efficiently from the waste tailings. These middlings would then be reground and re-treated. The final tailings fom the second jig would be tumbled in a ball-mill to abrade off the zinc mineral from the gangue, which would pass out under 1 per cent. zinc. The abraded zinc would go to flotation. Coarser initial grinding would be used to advantage under this scheme.

A list of the ore-dressing and gold-milling plants of the Western States has been published by the U. S. Bureau of Mines.[2]

The De Beers Co. is abandoning the weathering of diamondiferous earth and is crushing fresh-mined ore in gyratory breakers, thus adopting the practice followed by the Premier company since its commencement.

Treatment of Coal

General Ideas and Testing.—Interest is growing in coal washing so that while a few years ago the Robinson washer, jigs, the Scaife trough-washer, and the Campbell bumping table represented the wet apparatus used, we now have also in large application wet jerking tables of the Wilfley

[1] *Min. & Met.* No. 173, 20 (1921).
[2] *Rept. Investigations*, Serial No. 2287A-H (1921).

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type and some beginnings in installation of dry tables, froth flotation, the Trent process of flotation, and the Chance and Conklin processes of heavy-solution actions.

The concentration of coal may be roughly divided into treatment of coarse and treatment of fine. The former has been practiced for many years, using jigs, ascending current washers and trough-washers, and more recently wet tables, and also, if we include dry treatment, hand picking and automatic pickers. The treatment of fine or "slush," as it is called when these fines are mixed with water, has called for the use of the newer devices of wet tables, dry tables, flotation, and heavy-solution action, the wet work requiring Dorr apparatus to get rid of excess water.

In connection with coal testing and washing the U. S. Bureau of Mines has a large amount of work under way. The work of the Seattle Station has to deal with ash reduction in the high-ash low-sulphur coals of the Pacific Coast and Alaska, while the Urbana, Ill., Station devotes itself more to the occurrence and removal of sulphur in coal, including both the pyrite and the organic sulphur.

The work of the U. S. Bureau of Mines has brought out some new points in connection with coal testing. The Delamater float-and-sink apparatus of standard size is too small for coarse coal, and therefore has to be made in a large size for use on this material. This apparatus also has the fault of giving results which vary considerably on the same sample, depending on the fineness to which it is ground. In other words, the finer the grinding the greater the percentage that sinks. It is believed that this is due to gases filling the pores in the coal. The remedy is to wet the coal thoroughly or to exhaust the gases by means of a vacuum pump.

It is being recognized that a knowledge of the theoretical principles of coal separation should be understood and that a thorough study of impurities in coal by chemical, mineralogical, and microscopical methods is of much help in selecting proper coal-washing methods, and a report of work along these latter lines has been made by R. Lessing,[1] while in a memoir on coal washing J. de Gaux[2] has made a complete mathematical discussion of the laws governing the separation of minerals by settling in water and on jig beds, and illustrated the application of mathematical formulas to commercial coal washing where it is desired to determine the economic results that may be obtained under any given set of conditions.

Aside from the treatment of raw coal, considerable attention has been given abroad to the recovery of unburned combustible from ashes, and a considerable measure of success is reported. Some work done in the

[1] *Coll. Guard.*, **121**, 259 (1921). From *Midland Inst. Min. Civ. Mech. Eng.*, Jan. 22, 1921.
[2] *Ann. des Mines de Belgique*, **22**, 1089 (1921).

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United States along this line using flotation has given promising results, but the work of the U. S. Bureau of Mines[1] did not show up so well. In one test the refuse from a well-operated chain-grate stoker plant was screened on a ⅜-in. screen and oversize crushed to pass a ¼-in. ring. These two products were separately washed on tables which gave a combined recovery of 20 per cent. of combustible in the form of a product analyzing 25.5 per cent. ash and having an average calorific value of 9754 B.t.u. The original refuse analyzed 63.2 per cent. ash.

One detail that has hindered progress has been the lack of highly trained technical men with full responsibility to direct operations. In the case of anthracite breakers, D. C. Ashmead[2] specifically recommends that the breaker foreman should be an independent superintendent with complete control of breaker operation including personnel, and not, as at present, under the mine superintendent.

Anthracite Practice.—D. C. Ashmead[3] in a comprehensive paper has traced the main features in the advances in the preparation of anthracite from the date of the first mine to the present. The subject is dealt with under the following headings: (1) Mining methods and their relation to preparation; (2) Methods of consumption and their effect on preparation; (3) preparation of coal in the early days. Recent practice is thoroughly discussed under the additional headings: (4) rolls; (5) shaker screens; (6) feeders; (7) chutes; (8) spiral pickers; (9) fireproofing; (10) air washer; (11) Conklin separator; (12) Dorr apparatus for recovery of anthracite slush; (13) jigs; (14) concentrating tables; (15) water used for wet preparation; (16) force employed at preparation plants.

The paper also includes descriptions of the following anthracite breakers as being representative of practically the entire anthracite field: Marvine breaker, Hudson Coal Co.; No. 1 breaker, Pennsylvania Coal Co.; Franklin breaker, Lehigh Valley Coal Co.; Wanamie breaker, Lehigh and Wilkes-Barre Coal Co.; Lattimer breaker, Pardee Brothers & Co., Inc.; Buck Mountain breaker, Lehigh Valley Coal Co.; Brookside breaker, Philadelphia & Reading Coal & Iron Co.; and the Palm breaker of the Lehigh Coal & Navigation Co.

Other breakers have been described by the same author as follows:[4] The Scott colliery breaker, Susquehanna Collieries Co.; the new breaker of the Buck Run Coal Co.; Weston colliery breaker of the Locust Mountain Coal Co.; the breaker of the cranberry Creek Coal Co.; breaker at the Pennsylvania colliery of the Susquehanna Collieries Co.;

[1] T. Fraser and H. F. Yancy, *Coll. Guard.*, **122**, 1794 (1921).
[2] *Coal Age*, **20**, 763 (1921).
[3] *Am. Inst. Min. Met. Eng. No.* 1099, Sept., 1921; No. 1108, Dec., 1921; *Trans.*, **66**, 422, *Coal Age*, **20**, 367, 409, 527 (1921).
[4] *Coal Age*, **19**, 171, 305, 618, 851; **20**, 127, 833, 955 (1921).

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and the new Woodward breaker of the Delaware, Lackawanna & Western R. R.

For anthracite slush treatment, see *Dorr Apparatus and Wet Tables*, later.

Crushing and Screening.—Rolls are still standard for anthracite, ball-mills are in successful use for finer crushing, and vibrating screens are finding a field as in ore dressing.

A new form of roll is the Pardee, which has the unique feature of synchronizing the movements of the feeder and the rolls.[1] The rolls proper consist of two overlapping sets of discs, one set of which has teeth while the other is without teeth. The toothed discs break the coal against the other set as fulcrums. The distance between adjacent discs is equal to the diameter of the pieces desired. Each coal particle is delivered with its major axis at right angles to the plane in which the rolls revolve by an ingenious spiral feeder. Thus only oversize particles are crushed. These rolls are in daily service at the Colerain breaker. Results are reported to be very satisfactory. In one test the material was crushed directly from broken to egg coal without any oversize, giving a total of 92.84 per cent. of prepared sizes.

In discussing the advantages of horizontal over inclined gravity screens for coal. W. S. Harris[2] states that the former are in many cases giving much better results than the latter. The advantages claimed are: (1) No choking; (2) no avalanching; (3) gravity acting perpendicular to the screen, giving positive sizing; (4) picking easier done on them; (5) less loss of mill height; and (6) less breakage of coal.

Ascending-current Washers and Jigs.—The latest forms of anthracite jigs have been described by Ashmead.

Improved results are being obtained by a new automatic discharge for slate on coal jigs in Belgium, which operates in such a way that the discharge orifice is opened by the pressure of the water at each piston stroke, the amount of opening being determined by the pressure of the water under the sieve. Thus if the slate bed on the sieve becomes thicker it offers more resistance to the rising water, which means more pressure of water, larger discharge-orifice, and more rapid discharge. Just the opposite effect occurs as the slate bed gets thinner.[3]

The Rheolaveur has crossed the Channel from France and a large washer is being erected in England to use it. It washes up to 3⅛ in. and down to sludge in different types. Details have been given by A. France Focquet.[4]

[1] D. C. Ashmead, *Am. Inst. Min. Met. Eng.*, No. 1099, Sept., 1921; *Trans.*, **66**, 422.
[2] *Coal Age*, **20**, 607 (1921).
[3] Dessalle, *Ann. des Mines de Belgique*, **22**, 1217 (1921).
[4] *Rev. des Mines*, **9**, 1, 289, 543 (1921). *Inst. Min. Eng.*, **62**, 222 (1922). *Coll. Guard.*, **122**, 1661 (1921).

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Dry Tabling and Jigging.—The Sutton, Steele and Steele pneumatic table, which has found a limited field in ore concentration for solving special problems, has been brought out during the past year for coal and is being hailed as a great success. Reports of results have been made by E. O'Toole[1] and by L. E. Wood.[2] Recent tests in a small plant maintained by the Central Pocahontas Coal Co., at Welch, W. Va., are said to indicate an average capacity of 6 tons per hour on screen-sized particles ranging from ⅛ to 1½ in. A test on 1½-in. screenings from Pocahontas No. 4 bed reduced the ash content from 9 to 6.6 per cent., with a reject of 5.41 per cent. of the material treated.

Enthusiasm for the use of this table for coal has reached the point where some operators feel that no more wet plants will be built. This enthusiasm does not seem to be justified. The table will do good work and treat a good quantity of material, but it requires careful adjustment and there are still difficult problems to be worked out in applying it commercially to coal.

This same statement holds true with equal force for air jigs. Nevertheless the idea of applying dry tables to coal cleaning has had the effect of bringing out the old Plumb air jig for the same purpose. A preliminary test with this jig gave a clean coal concentrate, 96 per cent. by weight, with 93 per cent. carbon and 7 per cent. ash, and a slate tailing, 4 per cent. by weight, with 44 per cent. carbon and 56 per cent. ash.

Dorr Apparatus and Wet Tables.—Installations of Dorr Hydroseparators and classifiers in the anthracite fields increased over those of 1920, and in several installations concentrating tables were added to reduce the ash in the recovered coal. Also two large Dorr thickener plants were installed to prevent stream pollution.

Perhaps the most complete and interesting installation was made at the new Marvine breaker, where a Dorr Hydroseparator, eight Deister-Overstrom tables, and four Dorr classifiers were installed to recover coal below 200 mesh from the slush, with an ash content of below 14 per cent. This installation went into operation in September, and with a load requiring only 75 per cent. of the tables and classifiers installed, has recovered about 100 tons of coal per 8-hr. day from 3000 to 4000 gal. of slush per minute which will pass a 3/64-in screen. The recovered coal runs 13 per cent. ash and is being stocked as suitable for stoker fuel, pulverized fuel, briquetting, for the manufacture of anthracoal, or for sintering iron ores.

A similar installation was started in the fall of 1921 at the Coaldale breaker, where the Dorr Hydroseparator, five Deister-Overstrom coal

[1] *Am. Iron & Steel Inst.*, 11, 203 (1921). *Coal Age*, 20, 3, 53 (1921). *Coal Ind.*, 4, 340 (1921).
[2] *Coal Age*, 19, 810 (1921).

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tables, one Plat-O table, and three Dorr classifiers are to recover a low-ash coal from raw material for a briquetting plant. This outfit will treat about 2500 gal. of slush per minute through a $\frac{1}{16}$-in. screen and recover 250 tons per 8 hr. of coal analyzing about 16 per cent. ash.

A 90-ft. diameter Dorr thickener at the Sayre colliery handles 2200 gal. of slush per minute through a $\frac{1}{16}$-in. screen and recovers 90 per cent. of the solids in the feed as a high-ash product which is stacked. The main purpose of this installation is to prevent stream pollution, as is also the case with the 52-ft. thickener at the Hazelton shaft colliery, which treats 3500 gal. per min. of slush through $\frac{1}{16}$ in. and recovers the solids coarser than 200 mesh.

At the close of the year it was estimated that tables treating the thickened slush were recovering 10,000 tons daily of steam sizes of anthracite. At the Lytle colliery two Deister-Overstrom coal tables treat the thickened slush for use in a pulverized-fuel fired boiler-plant, and reduce the ash from 35 per cent. to 17 per cent., and also effect considerable saving of wear in grinding by the removal of pyrite and slate.

Tests of the Dorr apparatus at the Olyphant breaker, where the Conklin heavy-solution magnetite method is in use, indicate that the Dorr apparatus is more efficient than jigs for recovering the magnetite pulp from the products for return to the separator, and at the same time the finished coal is of higher quality.

At the Loree breaker the Dorr slush-recovery plant, which has been described in previous years, shows a direct operating cost of 5.3 cts. per ton, covering labor, power, supplies and repairs, and a total operating cost of 14.3 cts. per ton, including 8.8 cts. per ton to cover interest, insurance, taxes and depreciation at 20 per cent. on an investment of $17,500 for building and equipment.[1]

An economic study of the slush problem in anthracite preparation indicates that if recoverable coal in slush is converted into domestic fuel, it will add 9 per cent. to present domestic shipment of anthracite; and that even if no value be placed on the recovered coal, complete prevention of pollution can be accomplished at a cost, except under unusual conditions, of from 1 to 2 cts. per ton of breaker shipments. Six possible methods of utilizing anthracite slush are as follows: (1) Manufacture of briquets; (2) anthracoal; (3) hand-firing of furnaces; (4) stoker firing; (5) firing with admixture of birds-eye or bituminous coal; (6) pulverization.[2]

On bituminous coal the Renton Coal Co., of Renton, Wash., has been treating naturally classified material from the discharge-end of their sludge pond by an elevator and sluice to break up lumps of clay and coal,

[1] *Coal Age*, **20**, 608 (1921).
[2] J. Griffen, *Am. Inst. Min. Met. Eng.*, No. 1097, Sept., 1921; *Trans.*, **66**, 514.

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enabling concentrating tables to remove two-thirds of the ash, and thus making a good fuel. It is stated that each coal-washing table cleans 8 tons of sludge per hour.[1]

Electroprecipitation.—Tests have been completed under the supervision of the Pennsylvania Department of Health in which the solids were removed from washery water by electrical means with a power consumption of 9.5 kw. per ton of solids.[2]

Heavy-solution Methods.—The Chance and Conklin heavy-solution processes are both now in commercial operation. The former obtains the heavy-solution effect by the use of a mixture of fine sea-sand and water, while the latter employs magnetite dust and water. Both the processes have the advantage of being able to treat unsized material.

The Chance process has taken two years to pass from the laboratory stage to a commercial installation. At the West Nanticoke plant the apparatus has been in operation for six months, treating all the mixed coal from egg size down at an average rate of 25 tons per hour, although 60 tons has been put through per hour at times. The apparatus is in the form of a cone with stirring arms which make 14 r.p.m. The coal floats on the bed of sand pulp and is discharged from the top, while slate sinks and goes out through a discharge-gate at the bottom. Any sand coming off with the coal is removed by screening and washing with water. The results are considered extremely satisfactory, not only in cleaning as efficiently as jigs, but in being more economical and in causing less degradation or chipping of the clean coal. The Nanticoke cone is 7½ ft. in diameter at the top. An installation with a 15-ft. cone has been made at the Beaver Brook colliery, but on account of the anthracite strike there has been no opportunity to try it out commercially. The Conklin process is being tried out on anthracite in an experimental plant by the Hudson Coal Co.

Flotation.—Considerable advance has been made in working out the field and method of application to coal of both the froth-flotation process and the Trent process. F. B. Jones[3] has reviewed the froth flotation of and how it is put into practice, drawing conclusions as to the advantages of this method of treatment on various classes of material. Treating J. Durham coking-coal washery waste (South Wales) containing 45.3 per cent. ash, 2.8 tons of waste was required to produce 1 ton of product containing 8.3 per cent. ash. Washery silt from a Midland colliery was treated and 71 per cent. of the raw silt, containing 30.5 per cent. ash, was recovered as coal containing 9.6 per cent. ash, leaving a residue containing 86.5 per cent. ash.

[1] W. Strain, *Coal Age*, **19**, 741 (1921).
[2] *Coal Age*, **20**, 802 (1921).
[3] *So. Wales Inst. Eng.*, **37**, 33, 386 (1921). *Iron Coal Tr. Rev.*, **103**, 473 (1921). *Coal Ind.*, **4**, 505 (1921). *Coll. Guard.*, **122**, 1002 (1921).

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Although froth flotation has not received much attention from the practical men in the United States, it has been experimented on by the Western Fuel Corporation of Canada, by the Canadian Collieries, Ltd., and by the Granby Consolidated Co. The first named has gone so far as to install flotation in their new washery at Nanaimo, British Columbia, to handle picking-table refuse and sludge which were formerly sent to waste. The refuse is ground in a Hardinge ball-mill and classified, the coarse going to Deister tables and the sludge to Peterson flotation cells.

Comparing froth flotation with the Trent process on material ranging from 10 to 200 mesh, the latter seems to treat fine coal sludge better, while the former is better for coarse sizes. At 65 mesh both processes give the same results. At 200 mesh the Trent product is much cleaner. The Trent process lifts all the coal nearly quantitatively, so that it may be used as a method of analyzing froth-flotation products for carbon. Grinding even to 200 mesh will not give any separation of ash from bone coal by either process, but there is no difficulty in separating bony coal from slate.

A finely ground material is not so cleanly separated by froth flotation as coarser material. By the Trent process fine material may be very cleanly separated. The report of Minerals Separation work in England indicated that by control of reagents it was possible easily to separate the coal into the various fractions, but the U. S. Bureau of Mines experiments on coals of the Pacific Northwest showed this selective separation possible but by no means simple. The U. S. Bureau of Mines has not yet been very successful in attempts to float finely ground coke.

The Trent process, while not a froth flotation method, depends on the selective wetting action of oils on carbonaceous matter and water on mineral ash. Briefly, the process consists in gently agitating together finely crushed (200 mesh) coal, water and oil. The oil collects the carbonaceous particles, largely to the exclusion of water and ash. A plastic de-ashed fuel results, which has been called an "amalgam." The time taken for the operation has varied with different coals from 2 min. to 9 hr. When freed from most of its water, the "amalgam" may be shoveled, forced through pipes, and stored under water. The quantity of oil used is large, being close to 40 to 45 per cent. of the weight of the coal. Three products are distinguished according to the oil used. (1) Cheap fuel oil forms a good fuel without further treatment. (2) If an oil of low boiling point is used, it may be distilled off and recovered while the coal remains as a powdered residue. (3) If a heavy oil be used and the "amalgam" distilled to dryness, a coke can be produced, though the coal used may not be of a coking variety, and further the distillates are obtained in quantities often more favorable than the sum of the separate

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distillations of the coal and oil. In the results obtained, combustible recovery has averaged better than 95 per cent., ash reduction has been high with bituminous coals and anthracite, and sulphur reduction has been good with anthracite but poor in the case of bituminous coals. The U. S. Bureau of Mines has issued reports of various investigations in connection with the development of the Trent process.[1] The process has also been described by B. F. Haanel,[2] who also gives results of the treatment of various Canadian coals. Treating a sample from the Greenwood Coal Co., Nova Scotia, containing 16.18 per cent. ash, 72 per cent. of the ash was removed (using 43 per cent. of navy fuel oil) leaving 5.34 per cent. ash in the dry purified coal. Of the original carbon 98 per cent. was recovered.

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MINERAL STATISTICS

The following tables give in condensed form the mineral and metallurgical production of the principal countries of the world for a number of years past. Tables of imports and exports are also given for the chief countries. For the United States only the import and export tables appear here, since the production tables have been given at length in the various chapters. For many countries the 1921 figures are not yet available, while for some no statistics have been published for a number of years. On the other hand, it has been possible this year to supply data which had been unavailable for several years in the case of some countries. We are indebted to the U. S. Geological Survey for access to unpublished data from which many such figures were obtained.

Figures for the latest year are in some cases preliminary only; these are revised as soon as the final figures are issued. Where the preliminary figures are likely to differ greatly from the final, or where unofficial or estimated values have been used in the absence of official reports, such figures are printed in full-faced type. This has been done in few cases, however, since it is considered better to give such values only in the chapters making up the body of the volume where comment may be made on them, reserving these tables in the main for official data.

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AFRICA

The following tables give the mineral production of various countries in Africa. Provisional figures or estimates are given in full-faced type; other figures are official.

MINERAL PRODUCTION OF ALGERIA (*a*)
(In metric tons)

Year.	Antimony Ore.	Copper Ore.	Gypsum.		Iron Ore.	Lead-Silver Ore.	Mercury.	Onyx.	Phosphate Rock.	Salt.	Zinc Ore.
			Crude.	Plaster.							
1909...	163	67	.....	29,000	836,044	11,131	.....	200	345,385	17,817	81,852
1910...	4,475	112	.....	48,500	1,064,909	12,652	50	123	412,319	21,470	94,445
1911...	7,428	4,939	.....	51,760	1,025,643	17,909	.....	198	335,059	20,431	60,895
1912...	2,165	316	.....	54,400	1,225,625	24,516	.....	300	373,881	23,950	84,495
1913...	(*c*)582	13,164	700	50,399	1,349,000	13,953	18	168	377,934	26,969	82,256
1914...	1,947	1,090	.....	.....	1,180,943	25,986	.....	...	485,552	.....	81,961
1915...	9,022	*Nil.*	.....	.....	910,880	15,046	*Nil.*	...	225,871	1,875	16,796
1916...	28,473	1,098	.....	.....	1,042,865	23,731	32	...	380,211	3,910	28,973
1917...	16,800	.....	.....	.....	985,293	23,040	.....	...	202,539	.....	38,400
1918...	7,229	*Nil.*	.....	.....	902,465	13,060	15	...	189,419	96,784	20,263
1919...	2,160	410	.....	.....	735,579	8,457	8	...	242,186	16,986	13,268
1920(*b*)	2,966	601	.....	.....	1,114,438	12,804	0.2	...	334,704	15,236	27,716
1921(*b*)	320	2,007	.....	.....	684,964	11,421	*Nil.*	...	372,019	.....	17,357

(*a*) From *Statistique de l'Industrie Minérale.* (*b*) Exports, *Echo des Mines.*

MINERAL PRODUCTION OF EGYPT (*a*)
(In metric tons)

Year.	Gold, *Os.*	Gold, Value.	Lead and Zinc Ores.	Manganese Iron Ore.	Nitrate Shale. (*b*)	Petroleum.	Phosphate Rock.	Sodium Carbonate and Sulphate.
1912.....	4,958	102,482	3,510	.....	4,939	27,962	70,918	.....
1913.....	4,602	95,123	7,156	.....	4,740	12,786	104,450	.....
1914.....	6,136	126,831	4,909	.....	3,370	99,680	71,945	.....
1915.....	7,096	146,674	2,988	.....	4,271	30,054	82,998	.....
1916.....	6,287	129,952	.....	.....	3,950	57,743	125,008	.....
1917.....	3,319	68,604	.....	.....	4,347	136,845	115,732	3,527
1918.....	2,856	59,034	.....	27,498	4,520	281,885	31,147	3,486
1919.....	1,948	40,265	.....	48,734	3,940	224,300	29,365	1,431
1920.....	128	2,646	.....	77,562	4,743	147,950	114,813	1,981
1921.....	*Nil.*	*Nil.*	.....	55,065	3,656	182,668	122,024	563

(*a*) Statistics furnished by the Department of Mines and Quarries, Egypt. (*b*) Partial production, complete returns not available.

MINERAL AND METALLURGICAL PRODUCTION OF RHODESIA (*a*)
(In metric tons)

Year.	Antimony.	Asbestos.	Chrome Ore.	Coal.	Copper.	Diamonds, *Carats.*
1910.....	.....	.....	.....	163,357	.....	.....
1911.....	.....	.....	.....	192,806	.....	.....
1912.....	.....	*Nil.*	70,376	196,082	.....	587
1913.....	.....	295	64,405	220,747	.....	998
1914.....	.....	493	48,983	317,029	*Nil.*	1,005
1915.....	.....	2,042	61,556	371,737	1,028	.....
1916.....	39	6,256	90,302	445,918	3,578	1,021
1917.....	15	9,716	74,137	557,792	3,974	619
1918.....	15	8,712	31,789	499,177	3,306	450
1919.....	*Nil.*	9,956	35,850	518,252	3,059	386
1920.....	11	19,126	61,239	587,806	3,159	243
1921.....	*Nil.*	19,843	50,996	584,006	3,129	177

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Year.	Gold, Oz.	Gold, Value.	Iron Ore.	Lead.	Tungsten Ore.	Silver, Oz.
1910	609,956	$12,657,791	.....	679	.....	217,633
1911	628,521	12,991,500	.....	579	.....	187,641
1912	642,807	13,174,058	.....	533	.....	176,532
1913	689,954	14,261,343	.....	296	.....	142,390
1914	854,480	17,423,087	.....	152	1	150,793
1915	915,029	18,603,973	.....	25	4	186,233
1916	930,356	19,321,155	5,931	Nil.	3	200,676
1917	822,863	17,008,573	5,375	Nil.	11	211,939
1918	631,358	12,905,849	6,454	Nil.	37	175,722
1919	593,222	12,162,557	2,540	Nil.	20	171,995
1920	552,497	11,400,113	Nil.	Nil.	17	158,982
1921	585,525	12,102,802	Nil.	Nil.	17	152,989

(a) From Annual Report of the Rhodesia Chamber of Mines.

MINERAL PRODUCTION OF TUNIS (a)

(In metric tons)

Year.	Salt.	Lead Ore.	Phosphate of Lime.	Zinc Ore.	Year.	Iron Ore.	Lead Ore.	Phosphate of Lime.	Zinc Ore.
1907	78,200	18,600	1,069,000	22,800	1914	529,170	39,105	1,395,630	16,800
1908	149,600	37,500	1,300,500	26,500	1915	297,134	21,320	1,170,033	4,550
1909	118,400	41,600	1,300,000	24,500	1916	500,935	51,286	1,041,204	12,544
1910	199,700	(c)37,000	1,334,000	(c)32,500	1917	605,958	41,391	576,600	14,853
1911	.....	36,100	1,592,000	(c)27,900	1918	455,022	30,963	821,145	5,508
1912	.....	51,300	2,050,000	37,400	1919	349,464	15,433	1,075,214	5,054
1913(b)	594,199	52,200	2,170,500	30,300	1920	406,280	24,769	1,075,180	12,575

(a) From *Statistique de l'Industrie Minérale.* (b) From *l'Echo des Mines.*

MINERAL AND METALLURGICAL PRODUCTION OF THE UNION OF SOUTH AFRICA (d)

Year.	Antimony.	Asbestos.	Coal.	Copper Matte. (a)	Corundum.	Diamonds. Carats.	Gold, Oz.	Gold, Value.	Graphite.	Gypsum.
1914	.....	1,209	8,614,417	29,797	12	2,801,016	8,396,068	$173,546,726	35	1,820
1915	90	2,172	8,414,653	29,436	69	103,385	9,096,410	188,022,795	42	2,884
1916	734	4,731	10,168,623	23,210	767	2,346,330	9,296,963	192,168,225	61	4,054
1917	627	6,320	10,549,783	20,499	2,671	2,902,417	9,018,389	186,424,300	87	2,116
1918	90	3,332	8,958,709	6,191	3,516	2,543,735	8,418,217	174,017,845	72	2,393
1919	29	3,568	9,309,558	4,450	162	2,592,099	8,331,651	172,100,703	78	Nil.
1920	Nil.	6,452	10,408,716	9,866	237	2,551,665	8,158,455	168,635,365	66	.....

Year.	Iron Pyrite.	Lead.	Lime.	Magnesite.	Mica.	Salt. (b)	Silver, Oz.	Soda (crude).	Talc.	Tin. (c)
1914	.....	138	67,159	582	.....	40,939	890,781	2,635	.....	3,484
1915	554	183	70,100	637	2	45,830	966,176	6,404	45	3,496
1916	5,362	409	79,481	619	13	57,173	968,935	6,400	134	3,317
1917	2,902	274	90,491	794	4	.....	938,146	5,808	796	2,731
1918	4,200	147	92,782	754	5	.....	877,498	694	608	2,021
1919	5,019	686	.....	928	3	.....	891,304	47	686	1,477
1920	3,147	532	.....	1,286	1	.....	892,205	Nil.	618	2,224

(a) About 45 per cent. copper. (b) Including by-products. (c) Concentrates, 67.5 per cent. tin. (d) Official statistics of the Department of Mines and Industries. The figures correspond to sales or shipments in the year indicated, rather than mine output; the figures are in metric tons except where otherwise stated.

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AUSTRALASIA

In the following tables the production of minerals and metals in each of the Australian states and New Zealand is separately itemized. In the tables relating to foreign commerce, however, the states are not separately treated, the combined statistics of the Commonwealth now being officially reported. Figures in full-faced type are either provisional figures or estimates.

MINERAL PRODUCTION OF NEW SOUTH WALES (a)
(In metric tons or dollars; £1 = $5) (b)

Year.	Alunite.	Antimony and Ore.	Bismuth Ore.	Chrome Ore.	Coal.	Coke.	Cobalt Ore.	Copper Ore.
1907.....	2,021	1,780	17	30	8,796,451	258,683	*Nil.*	(g)
1908.....	1,099	119	9	*Nil.*	9,293,377	288,413	*Nil.*	(g)
1909.....	3,556	97	9	*Nil.*	7,132,548	207,553	*Nil.*	(g)
1910.....	1,154	99	7	*Nil.*	8,304,693	286,854	10	(g)
1911.....	1,023	168	9	*Nil.*	8,831,175	268,935	*Nil.*	(g)
1912.....	3,479	64	6	*Nil.*	10,044,487	245,050	*Nil.*	(g)
1913.....	2,269	18	9	*Nil.*	10,587,734	303,585	*Nil.*	(g)
1914.....	3,089	37	15	*Nil.*	10,557,911	309,677	*Nil.*	(g)
1915.....	1,443	646	18	*Nil.*	9,601,137	424,479	*Nil.*	(g)
1916.....	330	630	30	*Nil.*	8,258,008	444,632	*Nil.*	(g)
1917.....	1,817	306	5	596	8,431,081	436,180	*Nil.*	(g)
1918.....	.....	364	32	375	9,314,229	618,633	*Nil.*	*Nil.*
1919.....	2,525	261	20	254	8,770,522	431,612	*Nil.*	*Nil.*
1920.....	645	203	77	1,507	10,988,527	576,707	.....	.....
1921.....	.....	.....	.....	.....	10,967,160	601,630	.....	.....

Year.	Copper Matte, Ingot, and Regulus.	Diamonds. *Carats.*	Gold. (b)	Lead, Argentiferous. (f)		Lead, Pig. (f)	Molybdenite.	Opal.
				Ore.	Metal. (e)			
1907....	10,260	2,539	$5,112,852	441,024	20,687	20,084	22	$395,000
1908....	9,215	2,205	4,646,451	364,488	(h)	15,174	9	209,000
1909....	7,078	5,474	4,231,211	273,628	(h)	15,724	29	309,000
1910....	13,096	3,606	4,011,055	322,780	(h)	21,534	50	331,000
1911....	12,295	5,771	3,743,672	343,902	(h)	17,552	21	286,500
1912....	11,211	2,239	3,416,560	350,850	(h)	17,528	57	170,349
1913....	9,619	5,573	3,093,331	397,783	(h)	23,947	80	143,513
1914....	6,713	1,580	2,573,496	342,411	(h)	26,405	62	132,670
1915....	7,085	839	2,738,677	287,329	(h)	30,793	33	32,015
1916....	6,270	1,901	2,235,357	253,872	(h)	25,876	55	106,365
1917....	6,685	2,991	1,698,517	238,795	(h)	21,164	71	62,610
1918....	6,619	1,784	1,801,287	.....	.....	.....	95	103,000
1919....	1,484	1,774	1,360,855	421,088	(h)	11,870	67	146,290
1920....	1,317	1,706	1,010,908	9,453	(h)	427	41	23,600
1921....	.....	.....	1,057,684	.....	.....	.....	.....	.....

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Year.	Platinum. Kg.	Oil Shale.	Silver. Kg.	Tin.		Tungsten Ore.	Zinc. (c) (f)
				Ore.	Block.		
1907.....	8.6	48,088	63,573	(h)	1,945	409	241,015
1908.....	4.2	47,044	77,490	(h)	1,822	247	281,147
1909.....	13.7	49,500	53,430	(h)	1,974	129	379,907
1910.....	10.3	69,385	55,176	(h)	1,898	168	476,125
1911.....	14.6	76,306	54,975	(h)	1,960	288	524,666
1912.....	19.0	87,399	74,314	(h)	2,107	231	528,872
1913.....	13.7	17,268	68,267	(h)	3,071	172	515,105
1914.....	7.6	50,880	89,318	(h)	2,355	200	365,059
1915.....	1.7	15,723	100,698	(h)	2,223	84	193,988
1916.....	2.6	17,706	87,139	(h)	2,163	268	213,118
1917.....	8.1	32,189	55,420	979	1,127	120	273,020
1918.....	18.9	32,935	.....	.....	.....	.....	353,403
1919.....	6.6	25,954	292,838	1,571	1,165	218	74,637
1920.....	24.8	21,227	4,943	2,526	(h)	36	72,187
1921.....	.....	33,012	131,936	.....	.....	.....	.....

(a) From the Annual Report of the Department of Mines, New South Wales. (b) Where gold is reported, £1 = $4.866. (c) Spelter and concentrate. (d) Includes minor quantities of lead carbonate and chloride, the product of the leaching plant at Broken Hill. (e) Includes a small quantity of silver sulphide. (f) Exported. In the case of lead, 101,811 long tons was produced in 1912 from N. S. Wales in Australia. (g) Included with metal. (h) Included with ore.

MINERAL PRODUCTION OF QUEENSLAND (a)

(In metric tons or dollars; £1 = $5)

Year.	Bismuth Ore.	Coal.	Copper.	Gold. (b)	Lead.	Manganese Ore.
1907.....	6	694,204	12,959	$9,641,789	5,240	1,134
1908.....	22	707,473	14,932	9,613,051	7,207	1,403
1909.....	11	768,720	14,727	9,416,576	5,323	613
1910.....	22	885,108	16,649	9,123,531	2,435	805
1911.....	10	905,568	20,709	7,981,791	1,799	1,167
1912.....	(c) 201	917,202	23,505	7,191,846	3,179	313
1913.....	(c) 185	1,045,243	24,050	5,492,585	3,663	27
1914.....	(c) 197	1,071,237	18,738	5,156,919	736	6
1915.....	(c) 253	1,041,003	89,318	5,303,515	494	203
1916.....	(c) 139	922,341	19,833	4,569,755	625	653
1917.....	(c) 137	1,065,353	19,370	3,706,135	489	21
1918.....	(c) 137	999,022	19,285	2,760,827	225	1,320
1919.....	(c) 144	946,630	10,158	2,501,625	137	20
1920.....	(c) 51	1,127,783	16,153	2,382,885	1,736	15
1921.....	*Nil.*	970,135	2,467	1,052,192	1,074	846

Year.	Molybdenite.	Opal.	Silver. Kg.	Tin Ore.	Tungsten Ore.
1907.....	68	$ 15,000	28,662	5,222	627
1908.....	89	12,500	36,200	4,903	426
1909.....	94	10,000	31,140	3,379	617
1910.....	108	15,000	26,787	3,000	869
1911.....	(c)232	15,000	17,076	3,140	548
1912.....	104	14,600	17,712	3,284	636
1913.....	68	14,600	18,817	4,251	364
1914.....	79	9,700	7,899	2,119	245
1915.....	99	2,500	7,457	2,160	425
1916.....	83	2,500	7,561	1,734	376
1917.....	113	500	7,516	1,196	358
1918.....	112	1,500	4,743	1,333	253
1919.....	120	3,000	2,863	1,010	245
1920.....	29	2,500	8,528	1,510	84
1921.....	9	2,500	6,075	1,067	5

(a) From *Annual Reports* of the Under Secretary of Mines, Queensland. (b) Where gold is reported, £1 = $4.866. (c) Includes bismuth and some tungsten.

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MINERAL PRODUCTION OF SOUTH AUSTRALIA
(In metric tons or dollars) (a)

Year.	Copper.		Gold. (b)	Iron Ore.	Lead.	Lime-stone.	Phosphate Rock.	Salt.	Other Metals and Minerals.
	Ore.	Metal.							
1909.....	1,250	5,788	$146,932	16,379	142	13,986	3,833	52,232	$19,365
1910.....	.....	5,184	136,248	46,939	406	18,898	5,283	54,862	68,000
1911.....	.....	6,017	72,990	42,976	.....	29,159	5,893	66,040	56,600
1912.....	.....	6,395	136,248	42,877	.....	51,412	6,198	65,338	51,044
1913.....	.....	7,174	134,275	61,659	.....	45,038	6,049	66,083	104,906
1914.....	.....	6,996	129,343	43,324	.....	54,955	6,184	66,083	179,425
1915.....	.....	7,851	125,689	241,252	.....	72,895	4,689	65,066	207,140
1916.....	.....	7,396	160,578	191,381	.....	75,843	5,094	67,469	142,331
1917.....	.....	7,329	147,605	383,673	.....	69,566	5,183	47,612	228,444
1918.....	.....	7,284	127,742	261,167	.....	73,372	8,204	89,944	470,966
1919.....	.....	2,557	66,645	272,853	.....	46,129	6,046	70,288	285,377
1920.....	.....	4,409	35,079	419,688	.....	30,999	8,894	72,012	398,559
1921.....	.....	1,557	53,312	515,156	.....	44,990	5,161	57,401	237,913

(a) From *Mining Review*, Department of Mines, Adelaide, South Australia. (b) Where gold is reported, £1 = $4.866.

MINERAL PRODUCTION OF TASMANIA (a)
(In metric tons or dollars) (b)

Year.	Coal.	Copper Ore.	Blister Copper.	Gold. (b)	Iron Ore.	Lead-Silver Ore.	Tin Ore.
1908.....	62,044	1,204	8,974	$1,179,950	3,657	62,022	4,593
1909.....	67,224	1,613	8,472	951,005	*Nil.*	81,668	4,583
1910.....	83,763	682	8,324	765,784	*Nil.*	52,047	3,760
1911.....	57,980	2,323	6,118	628,375	*Nil.*	62,489	4,016
1912.....	54,366	1,414	5,218	784,320	*Nil.*	91,570	3,773
1913.....	55,960	2,000	4,645	690,369	*Nil.*	84,677	4,077
1914.....	61,807	3,343	7,634	542,437	*Nil.*	11,758	2,616
1915.....	65,612	67	8,031	383,450	(c)13,049	10,556	2,642
1916.....	56,470	98	6,406	326,372	(c)14,230	11,410	2,901
1917.....	64,433	784	5,922	299,634	(c) 7,809	9,730	2,680
1918.....	61,132	451	5,648	217,627	(c) 5,188	7,358	2,292
1919.....	67,320	.....	5,108	157,875	(c) 3,457	2,396	1,605
1920.....	76,643	.....	4,869	129,109	(c) 4,511	3,918	1,331
1921.....	67,546	.....	6,280	110,378	(c) 616	.....	804

(a) From *Statistics of the Colony of Tasmania*. (b) Where value of gold is reported, £1 = $4.866. (c) Included with lead-silver ore. (d) Not reported. (e) Iron pyrite.

MINERAL PRODUCTION OF NEW ZEALAND (a) (b)
(In metric tons or dollars) (c)

Year.	Anti-mony.	Coal.	Coke.	Copper Ore.	Gold. (c)	Kauri-gum.	Manga-nese Ore.	Silver. *Kg.*	Tung-sten Ore.
1908...	5	1,890,844	2	13	$9,755,303	5,618	*Nil.*	53,834.8	69
1909...	2	1,941,923	23	5	9,765,575	8,382	6	56,410.0	59
1910...	*Nil.*	2,232,610	*Nil.*	*Nil.*	9,227,532	8,832	5	52,176.8	145
1911...	20	2,099,284	*Nil.*	*Nil.*	9,105,000	7,587	1	40,775.2	140
1912...	.....	2,177,615	4	*Nil.*	6,427,422	7,908	.....	24,237.8	137
1913...	.....	1,919,472	28	.....	7,101,822	8,926	.....	30,344.6	225
1914...	*Nil.*	2,313,519	17	3	4,356,856	8,581	*Nil.*	18,636.4	207
1915...	*Nil.*	2,244,183	24	*Nil.*	8,245,695	4,650	*Nil.*	29,782.4	197
1916...	*Nil.*	2,293,475	34	*Nil.*	5,835,366	5,536	*Nil.*	24,479.7	270
1917...	*Nil.*	2,101,721	121	6	4,398,319	4,668	*Nil.*	24,482.8	164
1918...	13	2,067,001	71	*Nil.*	206,275	2,458	*Nil.*	27,351.4	172
1919...	*Nil.*	1,877,598	46	*Nil.*	6,493,215	4,194	*Nil.*	14,107.3	133
1920...	*Nil.*	1,873,389	20	*Nil.*	4,300,318	6,951	2	11,489.5	11

(a) From New Zealand Mines Statement, by the Hon. Roderick McKenzie, Minister of Mines, Wellington. (b) The exports are stated to be identical with the production, with the exception of coal (c) Where gold is reported, £1 = $4.866.

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MINERAL PRODUCTION OF VICTORIA (a)
(In metric tons or dollars)

Year.	Antimony Ore.	Coal.	Lignite.	Gold. (c)	Building Stone, etc. (b)	Tin Ore.
1907.....	4,575	140,802	*Nil.*	$14,377,166	$2,023,130	105
1908.....	3,740	115,283	*Nil.*	13,867,312	2,138,070	80
1909.....	1,779	130,230	*Nil.*	13,522,400	2,226,220	90
1910.....	1,283	374,775	660	11,789,077	2,542,815	42
1911.....	1,116	664,326	6,232	11,789,077	2,820,800	33
1912.....	2,470	598,599	4,076	9,924,032	3,385,070	48
1913.....	6,253	603,811	3,034	9,189,593	3,261,815	58
1914.....	7,730	627,828	2,760	8,540,978	3,485,880	54
1915.....	11,113	588,104	2,864	6,794,771	3,361,662	96
1916.....	12,581	423,900	2,962	5,304,884	.....	124
1917.....	2,613	473,726	39,774	3,172,595	3,171,274	141
1918.....	1,201	439,575	66,200	3,242,797	4,246,125	135
1919.....	1,208	423,946	111,628	2,799,215	4,743,737	113
1920.....	961	442,241	162,682	3,157,883	.....	85
1921.....	353	523,148	80,499	2,160,263	.....	81

(a) From Annual Reports of the Secretary for Mines of the Colony. (b) Includes bricks, tiles, pottery and salt. (c) Where gold is reported, £1 = $4.866.

MINERAL PRODUCTION OF WESTERN AUSTRALIA (a)
(In metric tons or dollars)

Year	Tungsten Ore. (g)	Coal.	Copper Ore. (g)	Copper and Matte.	Gold. (b)	Pig Lead (g)	Lead Ore. (dg)	Silver. Kg.	Tin (gh)
1910.....	2	266,361	6,410	1,301	$30,397,162	*Nil.*	252	5,478	509
1911.....	10	253,900	9,974	832	28,331,272	*Nil.*	1,575	5,215	502
1912.....	*Nil.*	299,815	9,689	28	26,511,841	*Nil.*	1,898	5,144	666
1913.....	1	319,048	4,411	(g)83	27,160,557	*Nil.*	3,222	5,848	496
1914.....	0.5	324,530	3,978	(g)186	25,484,960	*Nil.*	3,642	6,005	368
1915.....	0.3	291,281	749	(g)961	25,012,349	13	2,929	6,909	436
1916.....	1	306,381	660	(g)464	21,938,516	3,580	435	5,381	470
1917.....	*Nil.*	331,807	982	(g)544	20,055,935	4,736	22	6,907	390
1918.....	5	342,465	1,669	(g)486	18,117,482	5,577	287	3,416	422
1919.....	6	408,181	462	(g)4	15,172,738	1,809	252	6,946	323
1920.....	3	469,460	1,535	(g)139	12,770,794	1,961	3,485	4,065	247

(a) From the *Report of the Department of Mines of Western Australia.* (b) £1 = $4.866. (d) Silver-lead and lead ore. (g) Exports. (h) Ore and ingot.

MINERAL IMPORTS OF AUSTRALIA (a)
(In metric tons, cwt. of 112 lb., or dollars; £1 = $5) (b)

Year.	Cement. Cwt.	Coal.	Coke.	Copper Ore. Cwt.	Gold. (b)				
					Ore.	Bullion.	Specie.	In Matte.	Total Value.
1911	1,670,117	10,498	22,608	10,201	62,951	7,707,919	124,248	.....	7,895,118
1912	2,603,792	16,152	15,839	18,449	93,885	5,478,177	1,190,890	.....	6,762,952
1913	2,511,828	4,928	27,304	25,085	118,263	5,699,945	910,064	.....	6,728,272
1914(e)	1,040,494	14,085	10,887	11,736	71,311	2,670,213	973,200	.....	3,714,724
1915(f)	1,407,099	13,580	15,852	14,037	112,035	2,105,421	16,773	.....	2,234,229
1916(f)	1,516,858	6,186	1,734	16,257	162,529	2,648,749	32,179	.....	2,843,457
1917(f)	150,025	56,081	312	28,974	168,558	962,279	(c)	.....	1,130,837
1918(f)	11,017	32,888	*Nil.*	9,448	126,034	6,016,245	1,216,500	.....	7,358,779
1919(f)	372	57,770	*Nil.*	18,718	76,854	35,835,428	740	.....	35,913,022
1920(f)	112,739	35,765	4	3,380	39,726	238,293	92	.....	278,111
1921(f)	534,620	15,559	*Nil.*	1,100	31,921	32,777	63	20,014	84,775

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Year.	Graphite.	Iron and Steel.			Lead Mfrs. *Cwt.*	Petroleum Products.		
		Bars, Rods Girders, Sheets, etc. *Cwt.*	Galvanised Plates and Sheets. *Cwt.*	Pig and Scrap. *Cwt.*		Kerosene. *Gal.*	Benzine, Gasoline, etc. *Gal.*	Paraffin.
1911...	$38,910	4,215,936	(*d*)2,177,961	1,574,439	2 120	19,378,540	1,772,840	3,321
1912...	43,145	4,933,414	(*d*)2,416,367	1,719,535	955	24,292,539	12,294,617	2,832
1913...	48,925	5,070,590	(*d*)2,196,855	1,535,030	2,075	19,288,122	9,812,771	2,803
1914 (*e*)	26,595	2,377,790	(*d*)1,265,429	833,008	7,676	12,231,752	8,853,386	1,815
1915 (*f*)	41,795	3,236,889	1,676,033	1,352,011	2,650	20,444,196	12,446,797	2,790
1916 (*f*)	61,135	3,219,064	1,238,623	631,133	1,208	24,857,800	16,722,829	4,547
1917 (*f*)	44,246	2,020,416	452,590	376,515	426	22,626,762	20,412,125	2,463
1918 (*f*)	30,340	557,139	259,717	48,311	374	14,060,462	17,088,779	3,370
1919 (*f*)	33,970	885,408	562,823	24,949	277	16,672,962	20,748,976	3,361
1920 (*f*)	35,327	1,341,995	1,247,532	72,823	365	15,625,778	24,891,031	4,667
1921 (*f*)	51,360	954,920	2,592,560	65,460	340	20,080,019	35,069,489	2,335

Year.	Potassium Nitrate. *Cwt.*	Quick-silver.	Salt. *Cwt.*	Silver. (*b*)			Sulphur. *Cwt.*	Zinc, Bar and Sheet. *Cwt.*
				Ore. *Cwt.*	Bullion. *Kg.*	Specie.		
1911.....	10,257	42.4	753,849	1,734	1,115.8	$1,648,430	386,764	86,362
1912.....	10,127	52.8	468,507	3,836	1,580.3	1,350,870	465,643	61,736
1913.....	10,552	46.0	533,055	10,396	1,180.4	861,500	603,865	41,650
1914(*e*)...	6,349	20.9	139,024	.....	622.5	546,481	246,586	21,147
1915(*f*)...	7,500	24.0	372,160	319	586.1	2,062,386	421,497	29,193
1916(*f*)..	7,522	34.0	270,475	.....	174.2	1,068,988	825,648	12,303
1917(*f*)..	3,421	15.5	78,578	.....	143.0	218,814	991,780	3,743
1918(*f*)..	5,926	32.3	56,785	.....	15,558	251,728	792,904	4,775
1919(*f*)..	9,542	12.0	37,471	.....	11,848	120,482	592,063	4,449
1920(*f*)..	5,155	23.6	77,984	.....	428.2	39,688	678,017	5,966
1921(*f*)..	2,220	23.7	61,780	.....	618.4	52,952	1,425,640	326

(*a*) From Trade and Customs Returns, Commonwealth of Australia. Previous to 1900 each Colony reported its own imports and exports. (*b*) Where gold or silver values are reported, £1 = $4.866. (*c*) Included with bullion. (*d*) Includes ungalvanised corrugated. (*e*) First six months. (*f*) Fiscal year ending June 30th.

MINERAL EXPORTS OF AUSTRALIA (*a*)

(In metric tons, cwt. of 112 lb., or dollars; £1 = $5)

Year.	Alunite. *Cwt.*	Antimony Ore. *Cwt.*	Bismuth Ore. *Cwt.*	Cement. *Cwt.*	Chrome Ore. *Cwt.*	Coal.	Coke.	Cobalt Ore. *Cwt.*	Copper.	
									Ore.(*f*) *Cwt.*	Ingot and Matte. (*Cwt.*)
1911...	20,274	17,985	2,307	45,247	.....	1,714,939	8,543	.....	264,688	806,005
1912...	68,500	30,894	610	27,724	453	2,186,946	9,852	.....	259,690	876,773
1913...	44,700	51,007	588	18,221	.....	2,132,201	8,163	.....	177,757	846,411
1914(*g*)	24,200	30,661	151	23,813	.....	1,182,548	2,636	.....	62,658	392,005
1915(*h*)	52,400	50,316	1,295	24,591	.....	1,394,151	14,563	.....	142,363	669,189
1916(*h*)	12,800	74,631	2,602	27,345	.....	944,931	25,658	.....	89,382	737,841
1917(*h*)	6,500	51,995	1,883	15,406	.....	656,961	35,286	.....	602	721,785
1918(*h*)	.....	10,601	1,864	21,384	.....	362,466	37,901	.....	.....	541,416
1919(*h*)	6,400	29,039	477	32,914	.....	536,573	34,725	.....	.....	420,072
1920(*h*)	29,400	68,998	4,471	45,573	.....	1,029,640	34,766	.....	2,164	548,268
1921(*h*)	18,200	9,260	500	42,420	.....	2,196,142	59,099	.....	18,160	477,080

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Year.	Gold. (b)				Iron and Steel Bars, Rods, Girders, Sheet, etc. Cwt.	Lead.		
	Ore.	Bullion. (a)	Specie.	Total Value.		Pig. Cwt.	Contained in Matte. Cwt.	Manufactures. Cwt.
1911....	327,107	$10,456,322	$47,831,267	$58,614,696	116,893	1,358,308	397,342	14,610
1912....	340,474	9,135,487	50,801,322	60,277,283	138,061	1,438,681	502,264	17,916
1913....	371,257	6,695,757	10,184,007	17,251,021	184,433	1,529,075	524,513	14,989
1914 (g).	45,825	2,119,722	4,882,690	7,048,235	71,337	676,457	376,587	10,239
1915 (h).	255,883	3,325,439	9,447,081	13,028,403	179,122	1,427,455	737,416	14,190
1916 (h).	125,144	5,053,472	46,308,413	51,487,029	221,548	1,636,974	821,160	10,368
1917 (h).	4,705	1,735,288	54,768,149	56,503,437	269,013	2,372,935	548,880	14,895
1918 (h).	.....	162,880	30,950,320	31,113,210	80,307	1,904,856	311,659	23,366
1919 (h).	.....	10,374	10,815,819	10,826,193	352,245	2,071,721	.....	29,772
1920 (h).	.....	1,104,718	25,892,244	26,996,962	595,904	1,480,602	16,365	13,925
1921 (h).	.....	43,346	25,806,456	25,849,802	249,460	395,380	24,160	22,440

Year.	Molybdenum Ore. Cwt.	Salt. Cwt.	Shale, Oil.	Silver.		Tin.		Zinc, Bar and Sheets. Cwt.
				Ore. (d) Cwt.	Bullion. (e) Kg.	Ore. Cwt.	Block. Cwt.	
1911.....	1,876	63,607	6,344	(f) 3,226,043	218,387	(f)55,721	82,935	1,050
1912.....	2,873	123,779	290	(f) 2,395,267	238,947	(f)64,704	77,501	15,971
1913.....	2,684	134,863	449	(f) 3,377,901	252,219	(f)89,384	68,392	12,236
1914 (g)..	2,009	47,560	283	(f) 1,701,932	126,139	(f)42,616	27,624	.....
1915 (h)..	2,080	111,001	457	(f) 553,173	213,102	(f)42,845	29,891	54,099
1916 (h)..	2,569	312,525	20	(f) 195,565	205,019	(f)48,111	68,690	46,132
1917 (h)..	3,525	244,377	19	(f) 61,713	174,524	39,931	61,085	43,325
1918 (h)..	3,341	316,234	.....	(f)	162,168	3,806	73,199	15,363
1919 (h)..	4,007	256,118	5	(f)	355,826	.....	64,038	56,246
1920 (h)..	4,573	217,132	.....	(f) 42,878	148,168	.....	68,131	35,636
1921 (h)..	2,480	60	.....	(f) 41,840	16,750	400	41,120	66,420

(a) From Trade and Customs Returns, Commonwealth of Australia.—Note. Previous to 1900 each Colony reported its own exports separately. (b) Where gold or silver values are reported £ =$4.866. (c) Included with iron ore. (d) Includes lead ore. (e) Includes that contained in matte (f) Includes concentrates. (g) First six months. (h) Fiscal year ending June 30th. (i) Silver-lead bullion.

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AUSTRIA-HUNGARY

In the following tables the mineral and metal productions of the two Kingdoms are reported separately, together with that of Bosnia and Herzegovina. Exports and imports are reported jointly.

MINERAL AND METALLURGICAL PRODUCTION OF AUSTRIA (*a*)
(In metric tons)

Year.	Alum.	Alum and Pyritic Shale.	Antimony.		Asphalt and Asphaltic Rock.	Bismuth Ore.	Coal.	
			Ore.	Metal.			Bituminous.	Lignitic.
1903.....	*Nil.*	2,978	41	14	1,298	9.7	11,498,111	22,157,521
1904.....	*Nil.*	2,337	103	36	1,435	1.7	11,868,245	21,987,651
1905.....	*Nil.*	1,657	1,673	90	4,363	1.7	12,585,263	22,692,076
1906.....	*Nil.*	1,020	1,071	*Nil.*	2,840	2.7	13,473,307	24,167,714
1907.....	*Nil.*	*Nil.*	910	207	3,858	*Nil.*	13,850,420	26,262,110
1908.....	*Nil.*	*Nil.*	193	162	3,695	*Nil.*	13,875,382	26,728,926
1909.....	*Nil.*	*Nil.*	450	*Nil.*	2,975	*Nil.*	13,713,043	26,043,716
1910.....	*Nil.*	*Nil.*	225	*Nil.*	1,066	*Nil.*	13,773,985	25,132,855
1911.....	*Nil.*	*Nil.*	270	.....	1,740	.....	14,379,817	25,265,334
1912.....	.....	.....	4,520	13	4,234	.....	15,797,890	26,283,690
1913.....	.....	.....	1,270	.....	8,026	.....	16,459,889	27,378,332
.....	.....	.....	.....	.....	.....	.....	.....	.....
1919.....	.....	.....	50	.....	.....	.....	904,720	2,006,773
1920.....	.....	.....	.....	.....	.....	.....	132,864	2,408,865

Year.	Copper.			Cop-peras.	Gold.		Graphite.	Iron.	
	Ore.	Metal.	Sulphate.		Ore.	Bullion.		Ore.	Pig & Cast.
1903.....	8,188	961	310	298	2,148	$5,316	29,590	1,715,984	970,832
1904.....	10,701	889	808	414	12,653	47,183	28,620	1,719,219	988,364
1905.....	10,677	870	540	116	35,937	133,218	34,416	1,913,782	1,119,614
1906.....	20,255	877	578	154	33,033	83,401	38,117	2,253,662	1,222,230
1907.....	10,400	592	579	*Nil.*	30,711	92,471	49,425	2,540,118	1,383,524
1908.....	8,381	683	556	*Nil.*	28,907	98,504	44,425	2,632,407	1,466,897
1909.....	11,826	985	591	70	29,709	98,295	40,710	2,490,277	1,465,051
1910.....	8,005	1,468	715	30	31,744	118,895	33,131	2,627,513	1,504,786
1911.....	10,974	1,760	767	*Nil.*	29,647	134,840	41,599	2,765,815	1,596,148
1912.....	17,354	3,057	884	40	30,192	134,543	45,375	2,926,686	1,759,850
1913.....	16,353	3,685	897	40	35,994	186,714	49,456	3,039,324	1,757,864
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1920.....	23,751	648	.....	.....	.....	.....	8,265	250,520	61,880
1921.....	26,410	1,645	.....	.....	.....	.....	11,543	435,085	99,766

Year.	Lead.			Manganese. Ore.	Mineral Paint.	Petroleum.	Quicksilver.		Salt.
	Ore.	Pig.	Litharge.				Ore.	Metal.	
1903.....	22,196	12,162	923	6,179	1,691	672,508	83,321	523	359,015
1904.....	22,514	12,645	783	10,189	1,829	823,943	88,279	536	369,877
1905.....	23,339	12,968	865	13,788	798	794,391	86,856	520	343,375
1906.....	19,683	14,846	1,059	13,402	943	737,194	91,494	526	376,212
1907.....	22,792	13,598	863	16,756	1,091	1,725,808	89,370	527	395,053
1908.....	21,513	12,669	1,010	16,656	475	1,718,030	90,145	572	388,133
1909.....	20,550	12,941	840	18,045	620	2,086,342	92,337	585	359,801
1910.....	22,841	15,476	602	15,694	698	1,766,018	100,899	603	345,629
1911.....	23,845	18,097	318	15,954	2,902	1,487,842	111,018	704	342,732
1912.....	27,952	19,993	301	12,471	2,960	1,144,133	117,780	763	365,789
1913.....	25,751	22,312	305	16,540	2,999	1,081,090	130,608	820	337,563
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1919.....	(*b*)79,113	1,764	.....	.....	739	.....	.....	.....	95,932
1920.....	(*b*)78,351	3,973	.....	.....	476	.....	.....	.....	81,886

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Year.	Silver.		Sulphuric Acid.	Sulphur. Ore.	Tin.		Tungsten Ore.	Uranium.		Zinc.	
	Ore.	Bullion. Kg.			Ore.	Block.		Ore.	Salts.	Ore.	Spelter.
1903.	21,958	39,812	9,105	4,475	57	34	49	45.0	5.8	29,544	8,949
1904.	21,948	39,032	8,742	6,288	77	38	52	17.0	11.4	29,226	9,159
1905.	21,047	38,453	1,007	8,407	52	53	59	16.0	13.9	29,983	9,226
1906.	21,944	38,940	745	15,125	55	42	56	16.0	10.3	32,037	10,904
1907.	22,636	38,742	Nil.	24,099	53	47	44	11.0	11.2	31,970	11,208
1908.	22,241	39,867	Nil.	17,429	68	39	37	9.0	8.4	31,266	12,770
1909.	21,102	39,002	Nil.	12,725	36	52	39	18.0	10.2	33,955	11,688
1910.	23,629	49,692	.....	15,839	37	40	40	6.5	10.3	34,637	12,458
1911.	24,143	50,244	.....	15,805	944	15	45	5.8	6.8	32,166	15,766
1912.	21,794	49,355	.....	13,996	606	13	66	11.0	5.4	34,675	17,298
1913.	19,937	54,434	.....	10,561	939	11	52	11.2	4.5	34,225	19,508
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1919.	.....	.....	26	.....	.....	.....	.....	.....	.....	(c)	.....
1920.	.....	.....	126	.....	.....	.....	.....	.....	.....	(c)	.....

(a) From the *Statistisches Jahrbuch des K. K. Ackerbau-Ministeriums.* (b) *Includes Zinc ore* (c) *Included with lead ore.*

MINERAL AND METALLURGICAL PRODUCTION OF HUNGARY (a)

(In metric tons or dollars; 1 crown = $0.203)

Year.	Antimony.		Asphalt	Asphaltic Rock.	Bismuth.	Carbon Bisulphide.	Coal.			
	Ore.	Regulus.					Bituminous. (d)	Lignite. (d)	Coke.	Briquets.
1904...	1,080	1,007	2,221	17,660	0.9	2,512	1,155,320	5,519,349	5,103	103,481
1905...	949	756	173	19,372	1.4	2,760	919,193	6,015,452	69,303	144,697
1906...	1,807	954	4,111	34,664	2.0	2,756	1,103,529	6,229,712	79,930	151,657
1907...	2,035	841	3,920	33,096	0.4	2,950	1,038,819	6,408,322	97,447	154,783
1908...	1,316	670	4,818	72,972	(c)	2,966	982,017	7,034,499	141,954	109,178
1909...	1,971	695	5,054	.....	.....	3,086	1,397,424	7,658,719	157,415	117,594
1910...	1,939	782	4,994	.....	.....	3,245	1,302,103	7,734,166	156,048	108,873
1911...	2,616	892	3,861	.....	.....	3,488	1,290,182	8,154,560	145,104	118,412
1912...	8,380	859	4,460	.....	.....	3,692	1,302,405	8,287,871	149,913	118,505
1913...	11,017	1,048	3,025	45,860	(f)25	3,148	1,319,918	8,954,133	160,073	117,186
1914...	.....	753	.....	.....	.....	.....	909,882	.....	128,118	112,040
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1919...	759	.....	.....	.....	.....	.....	142,490	3,759,230	.....	.....
1920...	1,054	.....	.....	.....	.....	.....	167,920	4,795,140	.....	.....

Year.	Copper.	Copperas.	Gold.	Iron.			Lead.		Litharge.	Manganese. Ore.
				Ore. (d)	Pig.	Cast.	Ore.	Pig.		
1904...	63	1,277	2,437,988	1,524,036	370,297	17,203	(d)3,922	2,104	710	11,527
1905...	73	920	2,439,451	1,661,358	403,719	17,563	686	2,146	209	5,708
1906...	69	1,306	2,487,156	1,698,291	402,527	17,164	564	1,925	698	7,176
1907...	85	1,212	2,330,292	(e)622,518	423,134	17,103	8	1,468	441	8,198
1908...	166	1,372	2,189,801	(e)727,019	505,559	17,415	3	1,544	190	10,601
1909...	265	1,414	1,813,024	1,965,487	514,853	15,577		1,590	625	11,921
1910...	214	1,313	2,022,032	1,905,749	487,421	14,635	91	2,077	570	13,270
1911...	208	849	2,125,241	1,950,231	502,460	15,990	239	1,583	391	14,755
1912...	242	1,364	1,898,771	1,991,162	541,659	11,180	1,212	1,605	477	13,833
1913...	405	627	1,945,958	2,059,076	608,966	13,986	488	1,137	412	19,006
1914...	358	....	.....	1,722,340	494,441	.....	.....	1,368	.....	11,413
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1919...	.....	.....	.....	112,525	.....	.....	.....	.....	.....	100
1920...	.....	.....	.....	110,665	.....	.....	.....	.....	.....	.....

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Year.	Mineral Paints.	Petroleum.	Pyrite.	Quicksilver. *Kg.*	Salt.	Silver. *Kg.*	Sulphur.	Sulphuric Acid.	Zinc.	
									Ore. (*b*)	Spelter.
1902...	283	4,347	106,490	44,600	217,079	23,020	105	1,193	364	.....
1903...	263	3,010	96,619	43,700	214,536	19,281	135	1,543	46	26
1904...	273	2,134	97,148	45,169	230,943	16,352	143	1,329	203	.....
1905...	196	471	106,848	36,000	238,642	15,946	135	1,410	173	.....
1906...	221	2,692	112,623	50,100	245,402	13,642	133	1,457	243	146
1907...	259	2,404	99,503	40,400	(*c*)	12,695	(*c*)	1,232	(*c*)	(*c*)
1908...	294	2,427	95,824	78,000	(*c*)	12,612	144	1,444	135	(*c*)
1909...	63	2,590	98,971	71,500	231,182	10,932	131	1,307	(0)	.....
1910...	55	2,501	92,464	90,000	230,315	12,547	128	1,334	280	.....
1911...	69	2,191	96,755	79,700	239,006	10,806	51	938	106	.....
1912...	105	2,793	103,809	84,979	270,929	10,782	83	1,311	778	.....
1913...	57	2,105	106,629	88,800	256,448	8,696	42	555	407	.....
1914...	.....	.....	102,370	85,080	.....	.....	.....	.....	.....	.....

(*a*) From the *Annuaire Statistique Hongrois*. (*b*) Includes only that part of the crude output that was not smelted into a refined product. (*c*) Not reported. (*d*) Total production. (*e*) Exported. (*f*) Kilograms.

MINERAL AND METALLURGICAL PRODUCTION OF BOSNIA AND HERZEGOVINA (*a*)

(In metric tons)

Year.	Chrome Ore.	Copper.		Iron.		Lignite.	Manganese Ore.	Pyrite.	Quicksilver.	Salt.
		Ore.	Metal.	Ore.	Pig.					
1902...	270	3,657	166	133,348	43,992	424,753	5,760	5,170	7.2	17,348
1903...	147	1,073	191	114,059	39,833	467,962	4,538	6,589	8.1	18,459
1904...	279	640	115	127,297	47,678	483,617	1,114	10,412	8.1	18,021
1905...	186	670	39	122,540	43,074	540,237	4,129	19,045	10.0	(*b*)
1906...	320	765	25	136,513	45,660	594,172	7,651	11,347	5.1	22,671
1907...	310	245	*Nil.*	150,634	48,946	621,179	7,000	7,229	1.2	21,148
1908 (*c*)	315	(*b*)	*Nil.*	150,075	48,900	630,500	6,000	(*b*)	*Nil.*	22,100
1909 (*c*)	310	(*b*)	*Nil.*	145,200	48,850	675,400	5,000	(*b*)	*Nil.*	22,500
1910...	320	(*b*)	*Nil.*	132,720	48,841	706,659	4,000	571	*Nil.*	23,579
1911...	250	(*b*)	*Nil.*	140,283	44,354	769,763	3,600	3,118	*Nil.*	22,591
1912...	200	.....	*Nil.*	150,420	53,270	852,930	4,650	6,216	*Nil.*	23,124
1913...	305	.....	.....	220,131	53,587	841,140	4,700	7,701	.....	24,176
1914...	211	.....	.....	178,830	44,078	806,831	4,120	4,459	.....	25,730

(*a*) From *Oestr. Zeit. f. B.-u. H.* (*b*) Not reported. (*c*) Estimated.

MINERAL IMPORTS OF AUSTRIA-HUNGARY (*a*) (*g*)

(In metric tons or dollars; 5 Crowns = $1)

Year.	Alum.	Aluminium and Alloys.	Aluminium Sulphate and Chloride.	Antimony.		Arsenic. (*b*)	Asbestos.	
				Ore.	Regulus. *Kg.*		Crude. (*c*)	Manufactures.
1906(*f*)..	513	216	2,840	79	38,900	83	7,025	111
1907.....	545	255	3,200	231	89,900	325	5,729	180
1908.....	567	323	2,606	304	128,200	349	9,484	139
1909.....	359	418	1,831	95	80,100	370	12,003	200
1910.....	589	303	1,474	96	121,800	416	11,602	250
1911.....	375	516	1,317	98	124,600	377	16,071	276
1912.....	253	1,224	1,396	91	49,000	24	24,615	338
1913.....	454	589	1,334	.....	99,400	47	17,575	248
1914.....	969	405	1,295	.....	91,500	15	9,231	.....
1915.....	1,199	172	772	.....	7,800	8	489	.....
1916.....	463	154	4	.....	79,600	11	318	.....
1917.....	557	1,516	9	.....	2,500	2	111	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....
1921(*g*)...	575	271	1,250	.....	366,200	.....	815	.....

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Year.	Asphalt.		Barytes.	Borax.		Cement.	Chloride of Lime.	Chrome Ore.
	Crude Rock.	Mastic and Bitumen.		Crude, and Boric Acid.	Refined.			
1906(f).....	13,381	895	9,654	3,519	126	21,833	2,491	1,612
1907.....	9,394	1,637	11,669	3,763	138	23,697	2,534	2,795
1908.....	11,678	1,305	11,241	4,105	158	39,135	2,395	1,837
1909.....	9,113	1,309	13,940	3,240	139	53,262	3,105	2,223
1910.....	15,897	1,101	21,486	5,284	166	81,251	1,885	1,271
1911.....	18,394	1,990	20,501	4,407	193	80,613	3,131	2,217
1912.....	25,111	4,295	21,375	4,286	482	83,630	2,802	4,329
1913.....	24,794	5,221	23,350	5,652	356	61,261	3,097	2,845
1914.....	11,981	2,081	19,072	3,555	253	.....	1,530	33
1915.....	2,497	850	16,799	19	334	.....	525	*Nil.*
1916.....	1,796	1,004	14,827	535	372	.....	29	5,536
1917.....	1,656	340	9,930	71	4	.....	25	5,479
.....	.....	.....	.....	.....	.....	.....	.....	.....
1921(g).....	.....	.....	1,005	205	236	.....	.....	.....

Year.	Kaolin and Feldspar.	Coal.		Coke.	Copper.			Copper Sulphate
		Bituminous.	Lignitic.		Ore.	Bullion and Scrap.	Bars, Sheets, Wire, etc.	
1906(f) ...	13,219	5,942,897	17,464	406,088	267	20,943	481	1,597
1907.....	17,961	9,692,645	23,699	677,750	44	26,181	818	3,981
1908.....	17,417	9,995,415	30,433	851,099	121	33,270	1,140	8,402
1909.....	16,185	10,482,264	38,679	701,281	13	30,606	568	4,129
1910.....	17,817	9,864,462	37,867	670,089	49	32,217	926	3,445
1911.....	22,828	10,873,799	34,381	702,707	716	37,251	538	6,598
1912.....	24,628	11,848,535	34,871	(h)915,547	765	45,460	850	16,131
1913.....	22,467	13,689,154	33,107	933,669	150	36,481	572	6,937
1914.....	14,113	10,036,889	33,206	691,674	50	30,194	.....	7,273
1915.....	6,258	9,471,608	38,560	678,909	*Nil.*	7,069	.....	2,292
1916.....	7,244	12,025,034	36,788	821,768	14,514	9,162	.....	4,362
1917.....	5,482	10,449,630	26,734	739,308	15,128	8,902	.....	5,066
.....	.....	.....	.....	.....	.....	.....	.....	.....
1921(g) ..	(f)13,964	2,547,880	1,192,073	255,073	.....	4,023	.....	.....

Year.	Copperas.	Cryolite.	Fluorspar.	Gold. (d)		Graphite.	Gypsum.		Hydrochloric Acid.
				Bullion.	Coin.		Crude.	Burned.	
1906(f) ..	186	217	7,795	$989,604	$5,229,591	854	4,104	10,308	476
1907.....	187	613	8,779	1,106,002	5,755,918	934	5,813	11,981	629
1908.....	74	564	7,359	7,303,982	7,969,538	755	4,993	10,842	924
1909.....	56	556	8,106	36,744,037	8,631,453	660	4,907	10,410	898
1910.....	89	703	8,292	1,399,400	4,485,600	1,124	5,733	20,390	635
1911.....	66	944	9,446	3,163,554	1,902,798	1,173	6,616	16,489	612
1912.....	43	1,053	6,396	667,350	1,516,911	1,834	10,585	24,944	1,115
1913.....	53	635	10,204	514,051	3,626,938	1,499	8,696	24,659	985
1914.....	57	557	6,384	1,324,527	.....	978	6,726	17,517	735
1915.....	24	359	5,663	795,640	.....	293	4,237	10,741	90
1916.....	61	356	7,848	1,464,144	.....	141	4,516	8,988	1
1917.....	159	236	4,340	3,149,220	.....	69	2,925	6,556	1
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1921(g)..	383	.....	.....	.....	.....	725	498	.....	2,881

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Year.	Iron.				Lead.				
	Ore.	Pig and Old.	Manufactures.	Iron and Steel Bars, Sheets, Wire, etc.	Ore.	Pig, Alloys, Crude.	Litharge.	Red and Yellow.	White.
1906(f)	232,558	57,341	.....	5,085	189	11,732	82	310	75
1907	390,322	151,848	29,520	29,268	204	12,547	98	381	126
1908	423,940	224,740	45,235	88,396	559	17,116	161	616	201
1909	374,088	147,459	48,344	34,025	7,560	20,697	230	599	57
1910	307,190	185,604	51,869	44,277	6,354	17,065	411	574	139
1911	469,552	112,907	53,590	32,687	1,200	17,238	299	622	108
1912	628,867	244,532	64,621	48,137	3,240	16,961	403	448	94
1913	942,312	183,306	.....	.....	8,055	12,072	402	367	115
1914	598,055	78,926	.....	.....	10,612	3,163	186	144	131
1915	633,989	47,033	.....	.....	252	20,968	116	705	21
1916	573,781	214,519	.....	.....	56,004	21,875	320	998	24
1917	605,619	245,361	.....	.....	46,520	14,275	170	381	19
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1921(g)	.....	361,751	40,552	15,555	.....	1,098	.....	.....	.....

Year.	Magnesium Chloride.	Manganese Ore.	Millstones.	Mineral Paints.	Nickel, Old and Crude.	Nickel and Cobalt Ores	Nitric Acid.	Peat and Peat Coke
1906(f)	4,050	33 406	1,176	4,660	773	*Nil.*	12	1,918
1907	5,006	70,067	1,469	6,043	1,192	*Nil.*	12	4,460
1908	5,011	31,023	1,474	5,909	1,521	114	11	6,459
1909	6,095	44,970	1,357	5,773	2,116	*Nil.*	30	5,993
1910	6,616	59,951	1,510	7,340	1,606	*Nil.*	37	5,002
1911	7,171	78,790	1,494	7,157	1,598	0.1	27	5,115
1912	8,344	62,202	2,175	8,468	2,508	1.8	54	6,356
1913	7,810	67,278	2,066	6,984	1,895	*Nil.*	39	4,264
1914	5,654	55,538	.....	5,229	1,989	57	91	3,745
1915	4,591	204	.....	1,290	713	26	72	6,659
1916	3,546	1,052	.....	2,582	562	0.5	36	12,759
1917	6,404	152	.....	4,787	382	*Nil.*	1	16,484
.....	.....	.....	.....	.....	.....	.....	.....	.....
1921(g)	780	.....	.....	6,401	358	.....	.....	5,257

Year.	Petroleum Products.			Phosphorus and Phosphoric Acid.	Potassium Salts.			Pyrite.
	Crude Oil.	Refined Oil.	Paraffin.		Carbonate.	Chloride.	Chromate.	
1906(f)	13,522	9,693	403	178	602	3,729	(e) 5	87,973
1907	18,345	11,441	524	219	174	4,807	(e)38	130,270
1908	3,118	9,705	358	234	324	5,009	(e)98	130,793
1909	1,357	9,093	508	231	314	4,782	(e)86	141,858
1910	18,977	16,868	457	253	185	5,052	69	153,106
1911	19,070	19,737	632	233	201	3,666	55	150,974
1912	17,874	21,153	546	258	339	5,280	55	186,690
1913	19,151	31,590	299	255	157	5,216	175	130,526
1914	12,978	27,673	.....	.....	82	4,014	108	125,288
1915	3,330	115,060	.....	.....	19	5,118	39	17,091
1916	1,459	6,306	.....	.....	666	5,502	10	14,816
1917	20,838	2,381	.....	.....	730	6,741	21	6,223
.....	.....	.....	.....	.....	.....	.....	.....	.....
1921(g)	6,049	13,995	.....	.....	206	310	.....	7,451

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Year.	Quicksilver Kg.	Salt.	Sand.	Silver.		Slag and Slag Wool.	Roofing Slate.
				Bullion. Kg.	Specie.		
1906(f).....	1,800	32,182	134,526	43,000	$200,754	109,827	6,020
1907.....	1,200	41,660	180,280	88,182	170,228	107,783	7,537
1908.....	2,000	54,525	177,529	96,700	101,265	115,445	7,178
1909.....	2,600	75,397	183,169	150,980	172,201	155,812	6,915
1910.....	2,300	96,936	188,762	161,600	121,000	147,192	9,019
1911.....	2,900	99,921	225,743	195,000	70,102	147,179	8,060
1912.....	3,700	113,287	249,766	91,110	78,361	204,946	7,824
1913.....	4,400	110,923	235,775	148,580	206,032	214,726	6,351
1914.....	34,600	130,059	154,443	127,280	.....	.....	.....
1915.....	400	109,333	80,328	10,700	.....	.....	.....
1916.....	1,000	124,674	90,706	8,740	.....	.....	.....
1917.....	100	126,228	75,622	9,220	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....
1921(g).....	.....	14,543	19,809	13,270	.....	.....	.....

Year.	Sodium Salts.						Sulphur.
	Bi-sulphate.	Carbonate.	Carbonate (Calcined).	Hydrate.	Nitrate.	Sulphate.	
1906(f)	86	382	303	218	49,862	7,508	26,755
1907..	72	153	283	305	57,023	7,342	34,261
1908..	32	124	288	358	69,722	7,596	30,985
1909..	26	149	297	832	80,533	9,402	28,639
1910..	15	224	354	341	81,781	10,150	34,936
1911..	5	297	337	297	65,781	10,842	34,916
1912..	10	(i)455	260	302	92,838	14,454	40,913
1913..	12	164	262	102	93,035	12,682	39,228
1914..	3	110	225	73	73,191	8,671	31,786
1915..	138	99	215	53	19,998	4,448	12,759
1916..	120	11	42	26	31,618	1,859	1,758
1917..	16	5	13	6	23,319	2,250	200
.....	.....	.....	.....	.....	.....	.....	.....
1921(g)	.....	.....	252	.....	852	174	4,055

Year.	Sulphuric Acid.	Tin. Ingot, Crude, Old, etc.	Whetstones.	Zinc.			
				Calamine and Other Ores.	Spelter.	Bars, Sheets, Wires, etc.	White.
1906(f).....	17,020	3,320	4,377	24,014	19,467	595	347
1907.....	20,430	4,433	5,552	24,289	24,092	604	219
1908.....	25,251	4,295	5,916	19,366	26,472	1,010	361
1909.....	27,368	4,587	6,826	24,639	27,148	1,263	349
1910.....	27,421	4,674	6,915	30,880	29,168	1,898	511
1911.....	26,630	4,795	8,066	31,357	33,740	388	471
1912.....	36,714	4,806	6,826	35,376	37,558	1,260	438
1913.....	26,226	4,214	6,579	52,299	31,841	1,264	392
1914.....	15,078	4,091	.....	26,552	27,148	.....	271
1915.....	3,216	2,179	.....	15,721	29,569	.....	286
1916.....	7,366	959	.....	19,030	31,284	.....	254
1917.....	2,932	420	.....	14,746	24,163	.....	64
.....	.....	.....	.....	.....	.....	.....	.....
1921(g).....	2,143	524	.....	.....	1,898	.....	909

(a) From *Statistik des Auswaertigen Handel des Oesterreichisch-Ungarischen Zollgebiets.* (b) Includes arsenious acid and sulphide. (c) Includes burned asbestos. (d) The values of gold are figured at the rate of one crown = $0.203. (e) Potassium and Sodium. (f) Last 10 months only. (g) After 1920 figures are for Austria only. (h) Not including 188,884 tons of briquettes. (i) Includes bicarbonate. (j) Kaolin only.

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MINERAL EXPORTS OF AUSTRIA-HUNGARY (a) (c)

(In metric tons or dollars; 5 crowns = $1)

Year.	Alum.	Aluminium Sulphate and Chloride.	Antimony.		Arsenic, Metallic Oxide, Orpiment, and Realgar.	Asbestos.		Asphalt.	
			Ore.	Regulus.		Crude.	Manufactured.	Rock and Earth.	Mastic and Bitumen.
1906 (f).	68	80	314	912	66	376	1,708	2,824	799
1907	75	81	92	698	59	351	630	3,787	771
1908	147	92	161	527	51	442	450	1,312	1,030
1909	65	57	97	185	117	264	561	1,800	758
1910	346	85	54	416	9	262	604	1,545	954
1911	157	16	77	267	13	141	992	1,845	1,218
1912	253	7	54	689	2	530	779	1,357	1,920
1913	446	5	.....	323	.....	243	1,605	326	2,621
1914	412	11	.....	346	.....	282	.....	.....	.....
1915	172	15	.....	178	.....	156	.....	.....	.....
1916	12	156	.....	87	.....	226	.....	.....	.....
1917	224	277	.....	86	.....	555	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1921(c)..	193	.....	.....	69	.....	.....	.....	.....	.....

Year.	Barium.		Chloride of Lime.	Cement.	Chrome Ore.	Kaolin and Feldspar.	Coal.		Coke.
	Sulphate (b)	Chloride.					Bituminous.	Lignitic.	
1906(f)	2,395	4,503	271	64,883	102	133,326	750,420	7,150,339	246,914
1907 ...	3,119	5,220	308	81,407	161	157,894	849,792	8,876,408	323,243
1908 ...	2,987	2,974	519	65,597	144	154,146	762,867	8,600,683	183,279
1909 ...	2,585	3,737	462	63,463	174	150,878	633,253	8,241,723	198,313
1910 ...	13	4,344	1,213	98,888	140	164,859	615,082	7,492,447	230,735
1911 ...	12	3,741	1,175	168,321	70	174,493	609,737	7,063,931	299,915
1912 ...	2,690	3,658	1,518	149,860	95	187,358	655,106	7,442,392	349,384
1913 ...	733	4,918	2,042	144,596	142	197,693	708,997	7,016,606	369,802
1914 ...	1,780	3,947	973	.....	157	149,961	466,139	5,580,022	216,619
1915 ...	418	2,896	403	.....	751	119,897	1,123,232	5,169,413	50,909
1916 ...	538	2,954	1,203	.....	10,906	149,248	486,871	5,281,268	65,044
1917 ...	23	2,662	2,209	.....	18,896	129,680	181,685	3,950,675	46,839
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1921(c).	300	.....	600	.....	.....	338	13	2,988	11,921

Year.	Fluorspar.	Copper.			Copper Sulphate.	Copperas.	Cryolite.
		Ore.	Crude and Old.	Bars, Sheets, Plates, etc.			
1907.....	*Nil.*	489	624	870	11	1,580	*Nil.*
1908.....	7.0	206	1,126	791	63	2,199	*Nil.*
1909.....	12.0	136	1,250	541	40	1,877	*Nil.*
1910.....	4.0	101	977	700	83	2,273	42
1911.....	0.2	126	1,209	1,109	14	2,124	122
1912.....	13.0	516	1,332	1,642	119	3,090	46
1913.....	30.4	182	1,379	1,297	172	2,653	*Nil.*
1914.....	16.8	202	830	985	230	1,887	*Nil.*
1915.....	1.3	*Nil.*	120	12	91	2,425	1
1916.....	*Nil.*	2,290	1,258	5	139	2,212	3
1917.....	228.3	472	124	1	44	1,086	*Nil.*
.....	.....	.....	.....	.....	.....	.....	.....
1921(c).....	.....	110	1,141	.....	1,638	.....	.....

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Year.	Gold.			Graphite.	Gypsum.		Hydrochloric Acid.
	Ore.	Bullion. (e)	Specie. (e)		Crude.	Calcined.	
1906	936	$ 88,264	$8,015,967	16,871	1,970	686	2,942
1907(f)	996	1,234,291	13,061,517	21,704	3,841	801	3,708
1908	613	70,005	11,978,828	16,535	7,241	807	3,720
1909	548	3,426,539	19,470,382	18,484	3,675	809	3,263
1910	(h)	1,750,600	10,891,800	21,191	5,110	590	4,856
1911	(h)	6,909,408	15,220,358	21,204	3,689	914	5,834
1912	573	10,952,642	21,008,500	25,246	4,113	1,174	8,461
1913	102	2,092,318	13,719,496	24,492	2,544	988	8,969
1914	121	23,599,695	.....	16,531	1,366	1,401	5,697
1915	3,743	245,950	.....	22,877	273	130	3,900
1916	7,070	52,307	.....	33,773	215	187	6,462
1917	1,677	93,502	.....	39,243	543	45	2,897
.....	.....	.....	.....	.....	.....	.....	.....
1921(e)	.....	.....	.....	7,879	23,178		146

Year.	Iron.				Lime.	Magnesium Chloride and Glauber Salts.	Magnesite (Calcined).
	Ore.	Pig and Old.	Manufactures.	Iron and Steel Bars, Sheets, Wire, etc.			
1906(f)	234,924	43,694	73,575	50,247	87,468	4,094	87,765
1907	220,767	37,581	56,472	69,669	89,305	6,905	113,695
1908	220,357	17,494	32,110	29,227	62,938	2,622	87,049
1909	178,464	22,627	25,455	40,837	77,586	5,446	125,666
1910	144,827	96,114	73,473	100,541	391,989	6,332	182,911
1911	114,166	87,975	60,918	75,630	511,996	2,715	147,481
1912	111,436	50,328	48,147	49,907	583,812	2,212	171,196
1913	106,071	23,778	.....	.....	678,194	2,151	200,947
1914	58,051	41,567	.....	.....	403,374	1,695	133,099
1915	29,841	66,548	.....	.....	102,636	3,196	36,541
1916	14,440	3,414	.....	.....	60,424	7,866	38,527
1917	7,882	1,140	.....	.....	51,394	5,256	48,622
.....	.....	.....	.....	.....	.....	.....	.....
1921(e)	115,338	75,812	96,040	12,782	5,826	1,390	52,560

Year.	Lead.						Manganese Ore.	Millstones.	Mineral Paints.	Nickel and Cobalt Ores.
	Ore.	Dross.	Litharge.	Metal and Alloys.	Red and Yellow.	White.				
1906(f)	4,891	223	302	602	16	52	4,170	1,763	1,367	42
1907	8,360	420	255	197	9	54	5,273	2,422	1,697	29
1908	7,107	488	312	199	22	50	2,109	3,293	2,292	*Nil.*
1909	5,711	294	343	306	125	80	787	3,849	2,577	*Nil.*
1910	6,163	322	160	418	44	510	285	3,970	3,542	13
1911	5,493	154	768	670	24	35	588	3,513	3,426	1
1912	8,618	.....	28	548	19	82	534	3,530	4,272	0.3
1913	2,828	.....	36	1,060	3	32	550	3,083	3,831	4.0
1914	861	.....	4	863	12	74	237	.....	3,108	0.6
1915	126	.....	*Nil.*	340	13	194	168	.....	1,272	*Nil.*
1916	228	.....	*Nil.*	119	14	133	524	.....	2,694	0.1
1917	268	.....	*Nil.*	93	*Nil.*	44	3,984	.....	1,138	10.0
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1921(e)	279	.....	(j) 1,628	2,694	.....	359	.....	.....	3,608	.....

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Year.	Nitric Acid.	Ozokerite.	Peat and Peat Coke.	Petroleum. (d)	Benzine.	Paraffin.	Potash.	Potassium Chloride.	Pyrite.	Sulphur.
1906(f)	1,303	2,034	2,517	198,325	13,472	9,996	3,814	1,005	7,208	760
1907....	754	1,813	4,001	212,527	12,638	14,758	5,864	1,280	5,646	784
1908....	882	1,648	4,416	351,262	25,599	28,808	4,697	776	6,286	998
1909....	745	2,321	3,395	470,085	32,532	38,043	5,667	793	4,975	1,295
1910....	1,121	2,585	1,963	271,467	39,452	44,432	5,271	957	4,565	658
1911....	1,047	1,859	2,869	220,499	41,923	38,058	4,801	943	1,190	534
1912....	1,251	2,525	1,421	338,271	68,698	51,694	4,456	855	5,041	1,048
1913....	1,373	2,275	1,155	245,184	49,773	43,102	7,460	1,370	3,885	308
1914....	916	.....	.....	274,068	30,772	.....	7,152	933	1,950	183
1915....	49	.....	.....	139,286	523	.....	4,381	51	101	101
1916....	23	.....	.....	461,840	43,766	.....	3,263	55	*Nil.*	23
1917....	*Nil.*	.....	.....	382,795	11,943	.....	3,628	1,421	12,768	*Nil.*
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1921(c)	1,822	.....	.....	380	510	.....	.....	.....	445	98

Year.	Sulphuric Acid.	Tin.			Whetstones.	Zinc.				
		Ingot and Alloys.	Bars, Plates, Sheets, etc.	Dross.		Ore.	Metallic and Alloys.	Sheets, etc.	White.	Dross.
1906(f)	10,493	221	62	83	1,541	15,933	4,578	323	3,504	4,285
1907...	15,190	333	84	160	1,900	19,516	4,608	585	4,873	4,873
1908...	13,581	257	49	172	2,009	19,233	6,604	880	4,131	4,131
1909...	11,232	558	82	59	1,677	19,970	7,031	867	5,078	5,078
1910...	12,016	509	58	70	2,411	22,397	8,720	303	4,968	(g)
1911...	12,111	759	77	59	1,769	16,744	710	411	4,639	(g)
1912...	16,216	(i)1,038	42	.....	1,414	14,539	(i)10,356	2,483	5,890	.....
1913...	14,902	1,061	32	.....	1,358	16,376	13,174	1,249	5,514	.....
1914...	11,656	562	.....	.....	.....	9,826	10,320	1,309	3,917	.....
1915...	3,973	278	.....	.....	.....	3,841	2,777	2	2,324	.....
1916...	715	585	.....	.....	.....	1,622	1,591	9	2,525	.....
1917...	4,173	165	.....	.....	.....	2,685	*Nil.*	13	1,400	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1921(c)	233	229	.....	.....	.....	671	2,576	.....	.....	.....

(a) From *Statistik des Auswaertigen Handels des Oesterreichisch-Ungarischen Zollgebiets.* (b) Includes artificial barium sulphate. (c) After 1920, figures are for Austria only. (d) Where gold or silver values are reported, 1 crown = $0.203. (f) Last 10 months only. (g) Not reported. (h) Values in gold, $40,200 and $38,760. (i) Includes dross. (j) Including red and yellow lead.

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BELGIUM

Figures in full-faced type are either provisional figures or estimates.

MINERAL, METALLURGICAL AND QUARRY PRODUCTION OF BELGIUM (a)

(In metric tons except where otherwise noted)

Year.	Barytes.	Chalk-marl. *Cubic Meters.*	Coal.		Coke.	Flint. *Cubic Meters.*	Iron Ore.
			Bituminous.	Briquets.		For Earthenware.	
1907....	23,000	1,537,210	23,705,190	2,040,670	2,771,920	15,050	316,250
1908....	25,070	1,441,005	23,557,900	2,421,210	2,632,890	15,430	188,780
1909....	31,400	1,445,015	23,517,550	2,707,390	2,972,920	15,280	199,710
1910....	4,900	1,546,750	23,916,560	2,651,190	3,110,820	16,400	122,960
1911....	25,200	1,667,125	23,053,540	2,778,620	3,160,950	10,950	150,500
1912....	32,400	1,745,070	22,972,140	2,690,510	3,175,500	5,930	167,370
1913....	12,000	1,687,085	22,841,590	2,608,640	3,523,000	16,690	150,450
1914....	*Nil.*	1,051,160	16,714,050	1,799,700	2,001,670	5,400	82,360
1915....	*Nil.*	278,975	14,177,500	1,490,100	514,600	*Nil.*	4,720
1916....	*Nil.*	567,240	16,862,870	1,935,820	792,350	350	30,430
1917....	*Nil.*	374,380	14,931,340	981,930	676,040	*Nil.*	17,000
1918....	*Nil.*	245,500	13,891,400	1,140,600	522,210	600	500
1919....	*Nil.*	575,790	18,482,880	2,547,890	756,890	1,575	4,820
1920....	15,240	1,069,660	22,388,770	2,846,370	1,835,400	10,220	17,260
1921....	.....	.....	21,787,000	2,667,200	1,390,900	.....	.....

Year.	Iron, Crude.					Iron and Steel.			
	Foundry Pig.	Forge Pig.	Bessemer Pig.	Basic Pig.	Total Pig.	Ingots of Steel.	Merchant Bars.	Beams & Special Bars.	Tires.
1907....	92,280	189,190	88,650	1,008,170	1,406,980	1,521,610	594,170	327,930	34,700
1908....	76,290	116,740	78,950	996,870	1,270,050	1,249,620	544,810	241,060	29,000
1909....	91,040	127,080	56,430	1,340,060	1,616,370	1,580,350	628,740	291,260	33,960
1910....	82,410	115,760	55,650	1,596,970	1,852,090	1,892,160	672,730	340,850	31,860
1911....	52,970	102,690	46,240	1,836,720	2,046,280	2,128,170	711,220	380,160	35,450
1912....	94,810	66,940	44,250	2,093,480	2,301,290	2,442,420	609,930	390,340	40,320
1913....	93,830	66,370	32,260	2,291,390	2,484,690	2,466,630	855,550	213,940	34,140
1914....	60,310	28,660	44,390	1,316,450	1,454,400	1,396,300	489,360	131,860	15,150
1915....	26,260	3,150	14,730	19,780	68,150	98,820	76,670	9,555	2,930
1916....	58,805	17,040	17,400	36,540	127,825	99,371	121,765	12,630	2,630
1917....	*Nil.*	*Nil.*	2,460	5,530	7,990	9,530	44,510	4,730	750
1918....	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	10,540	50,720	500	240
1919....	43,670	*Nil.*	22,930	183,970	250,570	321,890	160,500	37,370	5,390
1920....	60,310	980	49,560	1,005,550	1,116,400	1,192,390	539,090	121,550	18,840
1921....	.....	.....	.....	.....	876,000	727,000	.....	.....	.....

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Year.	Iron and Steel.				Lead.		Manganese Ore.
	Rails.	Plates.	Sheets.	Total Wrought and Steel.	Ore.	Pig.	
1906.....	274,920	166,970	84,150	1,522,995	121	23,765	120
1907.....	314,760	148,690	82,420	1,575,110	210	27,450	2,100
1908.....	(c)191,370	135,390	93,790	1,296,050	195	35,650	7,130
1909.....	214,000	170,750	112,160	1,569,560	150	40,306	6,270
1910.....	347,890	177,110	122,830	1,834,050	162	40,715	*Nil.*
1911.....	337,520	211,410	130,250	1,945,220	82	44,308	*Nil.*
1912.....	339,060	251,380	119,390	1,903,270	107	54,940	*Nil.*
1913.....	341,870	241,200	138,570	2,162,210	132	53,590	*Nil.*
1914.....	152,750	160,640	81,900	1,238,780	52	45,560	*Nil.*
1915.....	29,470	16,895	20,970	164,370	121	16,770	500
1916.....	9,730	26,205	40,490	223,335	91	15,560	3,870
1917.....	730	10,360	12,660	75,150	35	22,745	2,020
1918.....	220	940	13,460	67,040	2	20,630	2,610
1919.....	53,960	52,020	40,270	411,055	*Nil.*	4,225	*Nil.*
1920.....	128,500	143,800	118,020	1,293,580	*Nil.*	16,040	*Nil.*

Year.	Mineral Paints.	Phosphate of Lime.	Pyrite.	Slate. *Pieces.*	Silver. *Kg.*	Zinc.			
	Ochers.					Ore (Blende).	Ore (Calamine).	Spelter.	Sheets.
1907	200	181,230	397	40,102,000	178,020	3,485	5	152,370	45,330
1908	.....	198,030	357	41,180,000	228,000	2,099	3	161,940	43,410
1909	700	205,260	214	41,630,000	271,270	1,229	*Nil.*	174,490	44,850
1910	600	202,880	214	36,440,000	264,655	1,434	*Nil.*	181,745	47,970
1911	540	196,780	122	37,620,000	252,720	836	*Nil.*	198,280	48,450
1912	650	203,110	148	29,600,000	279,960	1,167	*Nil.*	205,940	49,120
1913	600	219,420	268	27,390,000	253,940	949	*Nil.*	204,220	51,490
1914	300	105,330	109	16,430,000	141,590	410	*Nil.*	145,925	30,780
1915	*Nil.*	16,350	129	16,480,000	33,650	796	*Nil.*	51,680	21,350
1916	*Nil.*	77,740	212	19,460,000	41,060	602	*Nil.*	22,930	8,045
1917	*Nil.*	188,300	81	2,270,000	10,490	231	*Nil.*	10,290	1,675
1918	*Nil.*	61,700	6	680,000	4,900	17	*Nil.*	9,245	745
1919	*Nil.*	90,970	60	10,211,000	7,082	*Nil.*	*Nil.*	19,880	21,305
1920	200	133,040	*Nil.*	18,860,000	14,760	*Nil.*	*Nil.*	84,260	57,130
1921	.....	.....	.....	.....	.....	.....	.....	66,000	.....

(a) From *Statistique des Industries Extractives et Metallurgiques et des Appareils a vapeur en Belgique* d *Annales des Mines de Belgique.* (c) Includes beams.

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CANADA

The statistics of mineral production in the Dominion of Canada as reported by the Department of Mines are summarized in the following tables. The statement of imports and exports for 1907 is for the nine months ending March 31, in consequence of a change in the law whereby the fiscal year was changed from June 30:

MINERAL PRODUCTION OF THE DOMINION OF CANADA (a)
(In metric tons or dollars)

Year.	Arsenic.	Asbestos and Asbestic.	Barytes.	Cement. Barrels. (f)		Chromite.	Coal.	Cobalt and Oxide.	Coke. (k)
				Natural Rock.	Portland.				
1908....	634	82,448	3,911	1,044	2,665,289	7,341	9,857,754	841	784,788
1909....	1,024	79,197	(b)	*Nil.*	4,067,709	2,240	9,526,938	(i)	782,016
1910....	1,362	92,800	(b)	*Nil.*	4,753,975	276	11,711,000	(i)	818,450
1911....	1,902	115,136	45	*Nil.*	5,692,915	143	10,243,528	(i)	848,280
1912....	1,855	123,679	421	*Nil.*	7,132,732	(b)	13,168,941	(i)	1,275,829
1913....	1,535	146,169	581	*Nil.*	8,658,805	(b)	13,622,070	(i)	1,376,646
1914....	1,576	106,686	555	*Nil.*	7,172,480	123	12,336,088	(i)	921,241
1915....	2,174	124,123	499	*Nil.*	5,681,032	11,196	12,035,843	229	1,089,335
1916....	1,983	139,844	1,241	*Nil.*	5,369,560	24,962	13,139,386	381	1,314,335
1917....	2,663	139,510	3,166	*Nil.*	4,768,488	33,317	12,743,220	490	1,117,548
1918....	3,230	143,573	581	*Nil.*	3,591,481	19,953	13,587,974	334	1,141,515
1919....	2,896	144,458	*Nil.*	*Nil.*	4,995,257	7,749	12,411,600	241	1,052,778
1920....	2,231	181,153	681	*Nil.*	6,651,980	9,994	15,088,509	247	1,185,387
1921....	1,356	82,017	245	*Nil.*	5,805,237	2,087	13,555,762	84	.....

Year.	Copper. (In Ore, etc.)	Corundum.	Feldspar.	Gold. (c)	Graphite.	Grindstones.	Gypsum.	Iron Ore. (d)	Iron, Pig. All kinds.
1908..	28,895	988	7,144	$9,842,105	227	3,285	309,254	215,986	572,284
1909..	23,811	1,353	11,594	9,382,230	783	3,877	429,218	243,167	(g) 686,886
1910..	25,262	1,696	14,114	10,205,835	1,263	3,604	476,496	235,342	(g) 726,471
1911..	25,250	1,336	16,074	9,781,077	1,151	4,818	458,550	190,823	(g) 832,376
1912..	35,314	1,778	12,461	12,648,794	1,869	4,003	524,892	107,190	(g) 920,636
1913..	34,926	1,068	15,235	16,598,923	1,962	4,389	577,442	196,558	(g) 1,024,424
1914..	34,384	507	16,388	15,925,044	1,494	3,700	463,375	54,816	(g) 710,675
1915..	45,717	238	13,208	18,976,218	2,390	2,341	430,752	81,403	(g) 828,977
1916..	53,139	61	17,680	19,234,976	3,588	3,155	311,092	127,560	(g) 1,060,750
1917..	49,544	171	18,773	15,272,992	(l) 3,866	2,289	305,120	153,545	(g) 1,063,047
1918..	53,872	124	17,039	14,463,689	(l) 3,645	2,787	138,155	107,478	(g) 1,084,642
1919..	34,034	*Nil.*	14,464	15,850,423	(l) 1,397	1,872	275,787	5,337	(g) 832,619
1920..	37,014	178	34,358	15,812,695	(l) 2,080	2,216	389,319	8,060	(g) 989,137
1921..	24,230	365	27,706	19,106,811	361	.....	324,036	850	(g) 603,923

Year.	Steel. (h)	Lead. (In ore, etc.)	Magnesite.	Manganese Ore.	Mica.	Mineral Paints. (Ochers)	Molybdenite. (MoS_2 Content)	Natural Gas.
1908.....	534,117	19,593	109	.....	$139,871	4,305	.....	$1,012,660
1909.....	684,670	20,801	299	.....	147,782	3,573	.....	1,207,029
1910.....	745,963	14,963	293	.....	190,385	4,365	.....	1,346,471
1911.....	800,510	10,617	899	5	128,667	3,285	.....	1,917,673
1912.....	868,808	16,227	1,555	68	143,976	6,945	.....	2,362,700
1913.....	1,060,510	17,089	467	0	194,304	5,432	.....	3,309,381
1914.....	751,743	19,888	325	25	109,061	5,345	2	3,484,727
1915.....	926,157	21,009	13,407	182	91,905	5,668	13	3,706,035
1916.....	1,295,707	18,823	50,261	868	255,239	7,993	71	3,958,029
1917.....	1,583,786	14,776	52,699	143	358,851	8,536	131	5,045,298
1918.....	1,699,880	23,314	35,712	399	271,550	15,710	171	4,350,940
1919.....	934,726	19,880	10,317	600	273,305	10,761	38	4,176,037
1920.....	1,126,753	16,309	16,673	588	(m) 1,999	17,353	*Nil.*	4,232,642
1921.....	678,230	30,457	3,357	62	(m) 641	8,055	*Nil.*	4,902,020

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Year.	Nickel. (In ore, etc.)	Petroleum, Crude. *Barrels.* (*e*)	Phosphate. (Apatite.)	Pyrite.	Salt.	Silver. *Kg.* (In ore, etc.)	Soapstone and Talc.
1908.....	8,685	527,987	1,447	42,934	72,537	687,504	976
1909.....	11,922	420,755	905	58,645	76,237	856,263	3,945
1910.....	16,905	315,895	1,341	48,871	76,286	1,022,350	6,450
1911.....	15,457	291,092	563	74,978	83,065	1,012,586	6,621
1912.....	20,346	243,336	149	73,976	86,248	993,952	7,504
1913.....	22,539	228,080	349	143,882	91,457	990,538	11,115
1914.....	20,652	214,805	866	204,125	97,126	856,741	9,807
1915.....	30,985	215,464	197	259,494	108,773	828,067	10,782
1916.....	37,629	198,123	184	280,553	120,570	791,874	11,888
1917.....	37,344	213,832	135	377,984	126,018	691,148	14,336
1918.....	41,960	304,741	127	373,418	119,503	665,006	16,483
1919.....	20,204	240,466	24	160,109	134,539	498,290	16,912
1920.....	27,822	196,251	*Nil.*	158,528	190,380	414,614	19,660
1921.....	8,752	190,338	27	22,170	115,212	408,536	7,181

(*a*) From *Annual Report on the Mineral Production of Canada*, Department of Mines; latest year from *Preliminary Report*. (*b*) Not reported. (*c*) Gold values are calculated at the rate of $20.67 per oz. (*d*) Export. (*e*) One barrel contains 35 imp. gal. (*g*) From Canadian ore, 149,444 short tons in 1909, 104,906 tons in 1910, 42,186 tons in 1911, 36,355 tons in 1912, 73,508 tons in 1913, 95,744 in 1914, 158,595 tons in 1915, 115,691 tons in 1916, 46,022 tons in 1917, 47,444 tons in 1918, 38,457 tons in 1919, 68,828 metric tons in 1920, and 26,490 in 1921 (*h*) Steel ingots and castings. (*i*) 1909, $94,609; 1910, $51,986; 1911, $221,790; $320,244 in 1912. $695,855 in 1913; $678,619 in 1914, for oxides of cobalt and nickel; values received. (*j*) Bbl. of 350 lb each, sold or shipped. (*k*) Including that from foreign coal. (*l*) Including artificial graphite. (*m*) Tons, output.

MINERAL IMPORTS OF THE DOMINION OF CANADA (*a*)

(In metric tons or dollars)

Year. (*r*)	Aluminium.		Antimony. (*c*)	Arsenic.	Asbestos. (*d*)	Asphalt.	Cement.
	Manufactures. (*m*)	Ingots, Sheets, etc.					
1909.....	$30,076	$167,019	201	58	$181,710	15,979	$473,211
1910.....	42,493	424,006	232	12	198,756	19,661	159,040
1911.....	83,638	782,254	257	115	254,331	23,248	(*i*) 494,446
1912.....	119,070	487,490	233	159	349,655	28,291	(*i*) 936,425
1913.....	126,531	408,700	400	259	497,160	47,353	(*i*) 1,955,177
1914.....	151,261	730,012	322	127	474,499	48,564	(*i*) 852,134
1915.....	87,242	672,527	733	8	226,515	38,175	(*i*) 132,492
1916.....	85,574	700,365	595	146	191,886	38,029	45,295
1917.....	197,950	349,455	278	126	394,540	29,246	29,719
1918.....	224,449	318,444	216	199	528,054	18,229	17,417
1919.....	287,387	114,756	239	100	649,694	18,804	26,437
1920.....	436,468	862,296	584	210	734,302	18,621	47,156
1921.....	531,780	566,944	375	161	977,160	27,261	153,513
1922.....	432,960	165,923	314	7	491,478	23,726	34,304

Year. (*r*)	Coal.		Coke.	Copper.	Copper Sulphate.	Gold and Silver.
	Anthracite. (*f*)	Bituminous. (*f*)		Ingots, Pig, and Scrap.		Coin and Bullion. (*g*)
1909.....	2,775,680	6,526,797	423,013	1,239	963	9,988,442
1910.....	2,860,196	10,382,156	636,888	2,329	859	6,017,589
1911.....	3,144,130	7,785,259	692,292	2,279	772	10,206,210
1912.....	3,736,169	9,526,138	582,331	2,514	930	26,033,881
1913.....	3,844,062	10,034,383	644,207	2,581	1,153	5,527,979
1914.....	3,979,674	12,479,959	643,693	2,511	606	15,235,317
1915.....	3,971,968	8,279,570	460,381	2,053	335	131,993,031
1916.....	4,429,143	9,631,101	693,607	1,689	362	34,260,202
1917.....	4,144,488	11,730,145	686,389	2,308	921	28,081,120
1918.....	4,768,510	14,878,080	880,455	2,441	1,266	12,293,901
1919.....	3 511 710	15,031,419	988,855	1,921	1,146	.....
1920.....	4,618,345	10,480,800	346,193	2,840	1,085	.....
1921.....	4,380,469	13,978,134	499,075	4,424	1,068	.....
1922.....	4,006,427	11,568,668	210,628	223	686	.....

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Year. (r)	Graphite.		Gypsum.		Iron and Steel.		
	Crude.	Manufactures.	Crude and Ground.	Plaster of Paris.	Pig and Scrap.	Slabs, Blooms Bars, etc. (x)	Ferro-Alloys.
1909	$ 1,408	$75,608	9,359	7,712	62,967	43,263	13,571
1910	5,223	95,900	3,618	19,095	159,515	97,036	14,471
1911	4,300	97,057	11,443	19,664	266,269	139,060	15,773
1912	6,163	84,240	2,130	9,313	214,046	80,250	16,578
1913	6,105	89,719	8,800	28,975	306,927	77,176	20,837
1914	3,639	71,340	4,877	15,084	251,730	145,731	26,256
1915	1,464	43,313	3 236	5,769	69,261	50,086	2,534
1916	3,620	48,614	1,658	2,222	55,171	118,589	12,761
1917	3,008	102,960	3,069	3,548	70,482	73,270	12,069
1918	121,485	112,849	159	2,596	90,233	60,147	13,146
1919	21,203	142,698	213	986	118,782	51,468	31,157
1920	4,483	140,663	1,319	1,432	58,309	53,005	1,123
1921	5,615	156,951	4,453	2,931	178,968	112,081	8,191
1922	3,185	78,028	409	2,227	50,950	58,686	1,390

Year. (r)	Kainite.	Lead.				Lime.		Mineral Paints (Ochers).
		Pig and Scrap.	Bars and Sheets.	Litharge.	Pigments and Zinc White.	Burned. *Barrels.*	Chloride.	
1909	562	2,273	623	550	3,998	153,934	2,697	546
1910	687	5,755	580	915	4,433	191,527	4,554	914
1911	339	5,292	707	750	5,312	176,730	4,745	1,169
1912	262	10,934	1,356	745	4,921	230,013	5,584	1,358
1913	19	10,980	918	1,197	6,627	360,242	5,248	1,649
1914	180	5,078	654	512	7,547	.....	6,264	1,605
1915	350	7,539	358	479	5,350	.....	2,446	1,283
1916	44	22,928	477	1,043	6,090	.....	4,973	1,162
1917	174	5,473	450	1,147	7,274	.....	3,670	1,774
1918	355	5,564	429	1,081	7,471	(b)9,980	3,428	1,851
1919	80	4,619	372	835	8,198	(b)4,708	5,505	1,439
1920	755	5,459	283	919	9,531	(b)2,934	10,924	1,379
1921	1,271	10,943	318	983	8,068	(b)2,318	19,922	2,496
1922	11	676	81	776	7,527	(b)1,055	9,678	1,367

Year. (r)	Nickel. (s)	Petroleum Products.		Platinum.	Potassium Salts.		Quicksilver.
		Mineral Oil, etc., Crude or Refined. *Gallons.*	Paraffin Wax and Candles.		Except Saltpeter.	Saltpeter.	
1909	$ 67,107	13,095,593	103	$47,371	1,570	925	42
1910	98,238	(u)48,384,763	253	80,180	2,497	665	129
1911	137,114	(u)66,119,105	931	136,823	3,152	1,490	59
1912	135,227	88,916,283	808	190,770	3,734	1,049	49
1913	194,079	164,013,894	802	221,300	5,643	835	67
1914	144,343	202,540,731	717	121,336	8,057	776	115
1915	172,037	211,900,141	623	65,008	4,139	1,034	67
1916	239,495	213,670,889	549	100,415	1,706	850	83
1917	402,831	301,773,484	537	83,409	403	277	39
1918	293,611	384,572,804	1,004	98,507	125	425	41
1919	225,463	437,476,494	811	28,010	462	340	15
1920	230,565	417,573,844	662	197,835	3,749	280	24
1921	257,043	452,711,216	675	100,130	8,809	372	82
1922	90,935	500,245,161	772	98,887	4,493	242	16

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Year. (r)	Sal-Ammoniac.	Salt.	Silex.	Sodium Salts, Except Chloride.	Sulphur.	Tin and Tin-ware. (o)	Zinc.
1909 ...	162	119,660	417	33,787	19,981	$2,984,065	2,993
1910 ...	303	121,473	582	47,913	19,484	3,512,615	(p)7,606
1911 ...	346	111,174	468	62,969	22,935	4,235,848	(p)6,069
1912 ...	377	119,114	337	74,016	20,430	3,710,102	7,217
1913 ...	544	100,494	658	98,561	32,984	3,055,943	9,397
1914 ...	356	132,777	755	100,701	27,093	6,350,610	7,402
1915 ...	430	121,683	582	78,894	39,412	4,783,108	7,230
1916 ...	420	125,804	402	96,321	34,411	5,312,847	7,357
1917 ...	351	143,778	1,608	116,764	76,179	10,317,431	7,251
1918 ...	487	160,352	744	127,111	67,443	15,241,179	8,649
1919 ...	314	147,977	54	139,840	88,286	15,131,175	5,745
1920 ...	558	135,287	727	76,977	71,827	11,975,062	3,912
1921 ...	652	136,949	1,030	95,708	107,801	15,335,402	2,095
1922 ...	387	122,556	1,025	70,434	71,305	5,982,912	1,977

EXPORTS OF DOMESTIC MINERAL PRODUCE FROM THE DOMINION OF CANADA (a

(In metric tons or dollars)

Year. (r)	Antimony Ore.	Asbestos.	Chromite.	Coal.	Coke.	Copper. (e)
1909.....	1	54,188	3,707	1,548,468	70,024	24,642
1910.....	33	58,083	1,052	1,822,398	44,343	26,107
1911.....	222	63,348	14	2,100,309	54,380	24,950
1912.....	1	69,233	.....	1,436,798	13,677	25,595
1913.....	.....	83,299	.....	1,920,809	56,271	36,717
1914.....	.....	96,159	.....	1,360,029	66,512	37,772
1915.....	306	67,968	72	1,372,431	47,978	28,438
1916.....	970	80,611	10,649	1,788,679	39,737	52,995
1917.....	609	87,086	11,944	1,722,941	35,290	61,265
1918.....	604	128,005	15,805	1,725,503	23,599	53,824
1919.....	51	135,394	14,198	1,657,127	24,468	53,094
1920.....	*Nil.*	117,212	7,110	1,923,389	16,213	36,668
1921.....	*Nil.*	174,546	7,481	2,065,878	34,502	33,645
1922.....	*Nil.*	79,591	1,588	1,771,810	24,196	20,279

Year. (r)	Gold. Quartz, Dust, etc.	Graphite.	Grindstones.	Gypsum, Crude.	Iron Ore.	Lead. (p)
1909.....	$7,392,610	396	18,019	239,139	3,568	5,459
1910.....	6,110,473	1,164	13,754	304,736	28,608	8,395
1911.....	5,344,465	362	23,914	325,928	95,080	1,451
1912.....	7,211,438	1,395	30,513	324,324	34,162	52
1913.....	11,231,476	1,572	27,375	344,183	123,004	93
1914.....	13,326,755	1,367	54,584	359,287	103,126	125
1915.....	15,406,510	451	45,889	292,800	198,412	328
1916.....	16,870,394	366	19,971	348,923	75,212	1,406
1917.....	19,671,026	180	36,646	205,575	155,773	7,924
1918.....	13,688,700	65	29,767	182,320	143,258	7,343
1919.....	9,202,033	573	48,947	62,628	119,470	11,497
1920.....	5,974,334	1,459	35,719	149,428	6,790	9,521
1921.....	3,038,779	1,421	41,728	229,610	16,304	5,040
1922.....	2,532,050	570	24,997	202,007	4,341	18,560

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Year. (r)	Manganese Ore.	Mica.	Nickel. (y)	Petroleum, Crude and Refined. (q)	Pyrites.	Salt. *Bushels.* (w)	Silver (in Ore, Bullion, etc). *Kg.*
1909.....	3	243	8,895	q)195	23,087	3,040	733,248
1910.....	5	397	13,891	9,093	24,439	6,088	932,098
1911.....	2	370	15,771	1,493	32,396	6,625	1,049,153
1912.....	12	348	15,073	38,663	25,279	109,963	960,586
1913.....	7	415	21,849	152,746	3,109	60,536	1,096,835
1914.....	.....	321	22,949	25,443	42,006	165	1,143,337
1915.....	82	387	20,604	18,376	87,021	15,865	788,656
1916.....	489	392	31,912	512,443	131,598	9,227	864,527
1917.....	581	608	37,476	238,875	137,038	10,082	741,657
1918.....	143	544	37,671	93,174	254,122	102,173	683,048
1919.....	711	319	35,755	3,324,464	215,534	26,573	614,580
1920.....	550	3,072	20,022	5,358,836	75,872	17,728	385,044
1921.....	578	2,582	21,327	3,327,591	(z)108,053	8,347	413,392
1922.....	73	1,385	4,946	9,961,498	(z) 7,144	11,872	423,045

(a) From Tables of the *Monthly Report of the Trade of Canada.* (b) Metric tons. (c) Includes regulus and salts of antimony. (d) Asbestos in any form except crude, and all manufactures of. (e) Includes copper in ore, matte, regulus, etc. (f) Includes coal dust. (g) Coin, gold and silver, except U. S. silver coin. (h) Includes black lead and crucibles (clay or graphite). (i) Includes Canadian lead ore refined in the United States. (m) Does not include kitchen ware. (n) Includes chromic iron ore. (o) Includes tin plate and cans. (p) Includes lead contained in ore, etc. (q) Gallons. (r) Fiscal year ending March 31. (s) Includes silver-nickel and German silver. (t) Weight, 64,176 tons; 46,821, 247,940, 35,431, and 14,370 net tons. (u) Includes all oils. (v) Not including manufactures. (w) Using 60 lb. per bushel. (x) Does not include hoops, bands, sheets, plates, tubes, or finished structural steel. (y) Includes nickel in ore, matte, etc. (z) Sulphur content.

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CHINA

The official statistics of mineral imports and exports are summarized in the following table:

MINERAL IMPORTS OF CHINA (a)

(In metric tons)

Year.	Brass and Yellow Alloys.	Copper.	Lead.	Nickel.	Kerosene. *Gal.*	Quick-silver.	Tin.	Tin-plate.	Zinc.	
									Spelter.	Sheet, etc.
1912...	970	7,368	6,187	56	197,902,362	49	2,548	21,036	443	861
1913...	1,628	12,144	6,511	109	183,984,052	40	3,566	21,983	529	1,971
1914...	1,646	17,461	7,093	61	225,464,201	21	3,922	25,369	509	851
1915...	802	2,131	5,681	66	185,070,111	11	2,503	24,066	17	61
1916...	693	2,375	5,121	126	147,290,252	22	3,137	21,006	40	379
1917...	988	2,532	5,205	45	157,910,941	14	2,366	14,450	62	469
1918...	1,159	7,970	5,305	65	110,202,234	7	1,554	19,100	316	331
1919...	1,606	21,621	10,032	425	199,309,753	36	8,771	25,331	1,072	492
1920...	3,152	28,800	4,432	367	189,589,533	29	3,153	35,645	881	1,044
1921...	2,148	30,517	7,603	16	175,266,760	45	2,234	24,327	860	660

MINERAL EXPORTS OF CHINA (a)

(In metric tons)

Year.	Antimony.		Iron.		Lead.		Quick-silver.	Tin.	Zinc.	
	Ore.	Metal.(b)	Ore.	Pig and Mnfd.	Ore.	Pig.			Ore.	Spelter.
1912.....	2,054	13,531	355,538	12,604	4,276	20	4.3	8,786	7,170	760
1913.....	4,351	13,032	274,064	64,811	4,066	42	2.1	8,390	9,550	908
1914.....	4,972	19,645	299,515	60,068	3,722	235	59.7	7,215	7,374	310
1915.....	1,873	23,357	308,973	96,537	57	687	40.7	8,006	8,541	2,328
1916.....	12,958	24,740	311,932	159,475	9,899	1,244	177.7	8,403	452	803
1917.....	4,254	38,539	340,878	163,948	13,953	825	254.0	13,038	251	476
1918.....	480	16,568	378,682	190,514	944	463	292.0	8,820	166	129
1919	580	8,343	640,431	167,681	137	11	80.0	8,832	2	109
1920	1,352	14,282	682,950	198,377	2,391	330	45.5	11,487	9,116	98
1921.....	1,177	15,200	515,107	163,988	6,175	285	97.9	6,231	11,928	1,085

(a) From annual reports of the Imperial Chinese Maritime Customs. (b) Regulus and refined.

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FRANCE

In the following tables are given the statistics of mineral and metal production in France and the French colony New Caledonia, together with the foreign commerce of France in mineral and metal products. Figures in full-faced type are either provisional figures or estimates.

MINERAL AND METALLURGICAL PRODUCTION OF FRANCE (*a*)
(In metric tons)

Year.	Aluminium.	Antimony.		Arsenic Ore.	Asphaltum.	Barytes.	Bauxite.	Bitumen. (*c*)	Cement.
		Ore.	Metal.						
1911	7,400	29,267	4,775	19,000	39,000	10,064	254,831	170,000	1,795,000
1912	10,200	11,018	(*b*)5,406	81,880	31,535	13,620	258,929	312,000	1,924,277
1913	13,483	17,036	6,390	70,613	30,892	12,236	309,294	324,601	1,930,066
1914	9,962	3,416	1,545	250	22,170	.....	.....	166,125	.....
1915	6,017	6,353	2,834	1,300	10,179	.....	56,522	66,831	.....
1916	9,601	19,037	4,395	1,800	17,559	.....	106,200	98,480	.....
1917	11,064	19,453	4,534	344	12,964	.....	120,916	116,679	.....
1918	12,019	10,020	2,056	728	11,961	.....	.....	104,234	.....
1919	10,255	3,255	1,547	2,261	18,117	11,861	159,103	.....	1,185,704
1920	.....	3,880	.....	600	22,252	.....	186,693	.....	.....
1921	.....	4,411	.....	586	34,249	.....	84,942	.....	.....

Year.	Coal.	Lignite.	Peat.	Copper.		Gold.	Gypsum.	
				Ore.	Metal.		Crude.	Calcined.
1911	38,521,000	709,000	58,521	35	13,200	1,463,519	59,648	1,640,698
1912	41,145,000	751,000	43,000	242	11,907	1,993,620	25,900	1,700,000
1913	40,050,888	793,330	44,878	521	11,968	153,009	66,218	.....
1914	26,840,911	687,198	36,716	110	10,053	857,492	.....	.....
1915	18,855,544	677,388	20,096	95	850	143,519	.....	.....
1916	20,541,595	768,478	31,404	1,057	1,250	140,499	.....	.....
1917	27,757,411	1,157,996	52,099	1,377	1,000	101,659	.....	.....
1918	24,941,182	1,317,901	129,044	811	450	(*h*) 2,578	.....	.....
1919	21,567,009	909,757	71,068	38	873	(*h*) 10,224	19,974	825,863
1920	24,303,228	971,076	.....	373	.....	(*h*) 4,137	.....	.....
1921	28,242,887	735,608	.....	119	.....	(*h*)17,995	.....	.....

Year.	Iron.				Lead.		Lime.	Manganese Ore.	Millstones.
	Ore.	Pig.	Wrought Iron.	Wrought Steel.	Ore. (*d*)	Pig. (*e*)			
1911.	16,639,000	4,470,100	518,000	3,812,665	14,098	23,635	3,291,000	6,036	34,255
1912.	19,160,000	4,939,194	525,000	4,403,688	13,953	31,086	3,807,596	5,576	33,751
1913.	21,918,000	5,207,307	405,972	4,686,866	17,081	28,817	2,838,392	7,732	29,994
1914.	11,251,753	2,736,384	271,081	2,801,801	13,596	29,601	.....	6,393	.....
1915.	620,254	584,235	155,463	1,110,671	9,327	14,539	.....	10,324	.....
1916.	1,680,684	1,310,756	216,734	1,784,221	22,607	24,276	.....	10,807	.....
1917.	2,034,721	1,408,283	195,857	1,991,040	21,943	21,235	.....	11,589	.....
1918.	1,671,851	1,292,958	193,812	1,800,079	12,728	12,778	.....	9,871	.....
1919.	9,429,789	2,412,149	.....	2,186,260	2,211	11,104	.....	4,815	.....
1920.	13,871,187	3,317,371	.....	2,961,508	4,808	11,800	1,833,384	5,697	.....
1921.	14,116,706	.....	.....	.....	5,623	.....	.....	1,923	.....

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Year.	Mineral Paints. (Ochers)	Nickel.	Phosphate Rock.	Pyrite.	Salt.	Silver. *Kg.*	Sulphur Ore. (*g*)	Zinc.	
								Ore.	Metal.
1911....	34,542	1,180	312,204	277,900	1,339,000	47,277	1,200	43,761	57,111
1912....	41,810	1,725	313,151	282,202	1,099,000	63,736	1,000	45,929	62,650
1913....	56,240	1,500	298,859	311,167	1,281,978	31,268	659	46,577	67,896
1914....	.....	3,392	274,300	199,326	849,437	26,403	.....	46,057	42,473
1915....	.....	2,159	.....	196,606	799,902	12,801	388	23,778	19,180
1916....	.....	2,400	25,910	219,371	1,121,442	14,993	700	34,295	20,258
1917....	.....	1,918	.....	280,797	937,593	11,970	740	38,125	22,929
1918....	.....	713	.....	260,310	1,092,581	8,469	4,200	25,087	18,347
1919....	8,000	500	103,869	118,703	660,217	5,108	1,222	9,152	18,000
1920....	.....	.....	.....	132,443	826,556	.....	.....	5,494	20,141
1921....	.....	.....	.....	172,370	763,246	.....	.....	2,752	.....

(*a*) From *Statistique de l'Industrie Minérale.* (*b*) Not reported. (*c*) Includes pure bitumen, bituminous schist and sand, and asphaltic limestone. (*d*) Argentiferous lead ore. (*e*) Lead produced from native ores only. (*g*) Sulphur and limestone impregnated with sulphur. (*h*) Ores, tons. (*i*) Regulus and oxide.

MINERAL PRODUCTION OF NEW CALEDONIA. (*a*)

(In metric tons.)

Year.	Chrome Iron Ore.	Cobalt Ore.	Copper Ore.	Nickel Ore.	Year.	Chrome Iron Ore.	Cobalt Ore.	Manganese Ore.	Nickel Ore.
1906....	84,211	2,600	207	118,890	1913(*c*)	63,370	.....	.....	164,406
1907....	57,367	29,800	437	119,000	1914...	71,077	445	.....	172,000
1908....	25,371	2,360	(*b*) 10	108,000	1915...	22,142	140	.....	141,000
1909....	40,000	548	9,600	86,000	1916...	69,682	308	.....	105,000
1910....	40,000	54	8,000	99,000	1917...	54,800	96	.....	30,000
1911....	35,000	*Nil.*	1,900	142,000	1918...	55,177	48	900	90,650
1912(*c*)..	51,516	*Nil.*	.....	74,312	1919(*c*).	23,547	*Nil.*	2,416	5,372

(*a*) From *Statistique de l'Industrie Minérale.* (*c*) Exports. (*e*) Includes matte.

MINERAL IMPORTS OF FRANCE (*a*) (*k*)

(In metric tons or dollars. 5 f. = $1)

Year.	Aluminium.	Bitumen. (*f*)	Borates.	Bromides.	Cement.	Coal and Coke.	Copper.		Copper.	
							Ore.	Ingot and Mfrs.	Sulphate.	Oxide.
1906....	31	99,336	189	93	24,974	17,848,284	11,932	64,590	15,358	97
1907....	25	31,700	1,660	37	24,839	18,706,000	12,063	76,282	10,558	80
1908....	27	48,000	4,034	28	31,550	18,563,000	15,300	86,985	18,143	85
1909....	39	54,000	6,249	25	46,664	19,387,000	27,400	86,143	12,160	282
1910....	.....	36,360	8,322	17	51,905	18,145,872	23,362	93,548	11,887	427
1911....	.....	32,207	3,128	12	86,457	19,740,539	24,585	104,724	17,759	151
1912....	.....	39,508	3,277	20	115,286	19,878,477	19,671	112,148	16,800	134
1913....	94	58,215	15,149	9	120,620	22,866,967	9,653	138,510	21,575	96
1914....	57	38,470	9,209	11	69,349	17,637,149	10,717	89,140	24,071	62
1915....	100	25,596	1,245	103	28,375	19,693,599	2,758	126,127	33,868	10
1916....	739	24,381	7,230	72	10,919	20,213,833	1,591	175,009	20,943	12
1917....	1,350	12,343	3,900	6	13,402	17,295,370	4,030	249,138	43,214	63
1918....	7,786	4,859	1,788	0.1	5,427	15,903,509	427	166,781	42,645	6
1919....	4,843	13,258	6,030	8	12,023	20,929,281	1,096	56,942	17,266	34
1920....	1,399	11,007	7,161	78	53,420	28,052,181	2,845	73,980	16,166	24
1921....	287	24,502	3,947	13	31,891	20,891,786	6,564	48,813	15,411	41

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Year.	Cobalt Ore.	Iron.					Kaolin.	Lead.		
		Ore.	Pig.	Iron and Steel, Mfrs.	Sulphate.	Oxide.		Ore.	Carbonate.	Pig, Scrap, and Mfrs.
1906....	808	2,015,550	135,252	342,411	132	1,311	44,772	43,137	2,072	67,651
1907....	1,396	1,999,000	122,102	336,337	115	1,439	53,447	42,342	1,898	53,359
1908....	1,500	1,454,000	156,618	373,624	117	1,408	58,909	40,700	3,100	70,824
1909....	400	1,202,619	154,031	354,428	75	1,270	59,490	38,400	4,398	68,332
1910....	2.6	1,318,520	168,810	378,227	2,243	1,235	62,920	28,950	3,259	64,517
1911....	0.3	1,350,794	194,225	77,000	4,454	1,511	66,500	47,340	3,095	69,791
1912....	.....	1,454,190	86,637	114,100	2,800	1,466	63,783	42,499	2,919	65,449
1913....	.....	.....	49,612	202,754	3,370	1,544	61,255	39,772	4,041	77,790
1914....	.....	1,044,160	57,241	130,993	1,654	904	45,682	21,780	1,900	41,900
1915....	.....	397,348	166,397	1,133,898	1,755	295	14,003	15,991	1,010	51,700
1916....	.....	824,176	612,012	2,897,553	.....	322	29,346	40,750	3,255	63,739
1917....	.....	507,909	657,023	2,894,860	*Nil.*	314	23,590	36,048	2,114	57,846
1918....	.....	118,612	375,941	1,917,902	256	210	39,328	26,389	1,228	51,441
1919....	.....	303,852	95,097	1,322,443	265	631	38,390	11,968	4,702	55,432
1920....	.....	404,725	110,310	857,915	697	1,791	42,474	33,650	4,433	56,152
1921....	.....	425,027	34,939	379,154	923	1,234	24,056	13,998	3,014	33,583

Year.	Lime, Chloride of.	Manganese Ore.	Nickel.		Petroleum.	Phosphate Rock.	Platinum *Kg.*	Potassium.	
			Ore.	Metal.				Chloride.	Chromate. (*h*)
1906	593	127,235	44,960	480	(*g*)213,462	533,213	5,708	26,523	3,024
1907	232	192,448	45,892	979	(*g*)311,000	636,549	4,373	25,151	3,000
1908(*k*)..	70	170,500	42,200	1,281	(*g*)300,000	767,424	3,955	28,416	3,000
1909(*k*)..	141	177,314	12,200	.....	(*g*)300,000	645,178	5,914	27,248	2,583
1910	333	188,292	28,001	2,074	(*g*)271,500	687,675	7,795	34,974	3,009
1911	53	235,400	43,014	6,465	(*g*)375,000	740,375	9,392	39,508	2,991
1912	24	225,379	27,126	5,032	(*g*)360,000	903,490	6,236	45,174	3,178
1913	.....	258,929	10,292	4,046	.....	934,679	5,066	46,138	3,245
1914	.....	153,487	28,580	3,174	(*g*)488,555	661,429	2,921	30,352	2,330
1915	.....	12,591	19,004	3,892	472,696	325,114	360	699	3,473
1916	3,150	58,658	8,915	1,760	658,589	285,906	576	357	4,131
1917	1,363	77,356	5,152	1,871	629,188	134,779	473	1,424	4,108
1918	2,969	58,984	3,289	823	741,931	233,399	41	1,285	2,648
1919	5,027	104,973	10,350	1,059	683,456	502,641	219	1,048	3,668
1920	3,520	152,568	709	114	926,822	880,932	733	1,925	3,938
1921	2,503	179,634	*Nil.*	214	723,260	708,964	223	8,246	1,555

Year.	Potassium (*Cont'd*).		Pyrite.	Quicksilver.		Ammonia Salts	Salt.	Sodium.	
	Nitrate.	Carbonate.		Ore.	Metal.			Hydrate.	Nitrate.
1906	684	2,206	349,514	.....	242	18,146	38,361	614	244,191
1907	924	2,708	355,300	.....	216	29,357	30,000	611	246,920
1908(*k*) .	424	2,277	348,300	.....	180	32,651	33,000	550	299,390
1909(*k*) .	1,288	2,382	275,600	.....	191	25,825	30,000	567	258,743
1910	132	2,579	309,400	.....	146	27,360	49,800	577	345,160
1911	174	4,452	318,530	.....	196	23,200	47,200	550	317,725
1912	53	4,017	486,072	.....	213	25,056	39,500	556	354,776
1913	72	7,374	581,756	.....	198	24,253	32,966	562	322,115
1914	291	2,898	604,656	.....	167	10,009	38,681	1,922	297,190
1915	28	1,184	424,806	.....	330	32,827	32,990	13,002	254,008
1916	2,996	325	792,347	.....	568	.....	60,578	14,364	540,701
1917	2,641	465	491,620	.....	490	.....	23,213	19,949	453,665
1918	2,183	119	321,281	.....	852	.....	20,927	5,169	256,527
1919	2,789	838	95,363	.....	187	.....	44,924	1,541	166,686
1920	1,521	2,762	241,179	.....	212	.....	43,781	3,659	261,639
1921	624	3,313	334,264	.....	32	.....	.....	452	.....

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Year.	Sulphur.	Sulphuric Acid.	Superphosphate of Lime.	Tin.		Zinc.	
				Ore.	Metal.	Ore.	Metal.
1906	131,678	5,268	44,502	1,038	7,687	106,307	26,960
1907	106,050	11,027	29,154	961	7,693	114,699	33,503
1908(*h*)	195,000	10,082	42,878	1,000	8,482	137,900	40,312
1909(*h*)	196,300	11,845	65,560	1,900	9,633	120,600	32,749
1910	202,263	14,642	132,530	1,651	8,517	193,360	19,237
1911	267,969	15,150	79,385	2,544	8,456	160,180	42,785
1912	172,181	13,169	89,059	1,726	8,503	158,429	43,795
1913	186,344	11,001	100,882	2,542	8,722	178,719	39,997
1914	116,018	6,180	231,265	2,132	7,216	99,124	30,361
1915	102,757	25,741	43,144	220	8,914	49,398	36,825
1916	128,095	70,374	16,172	445	10,548	56,727	63,206
1917	78,187	55,739	1,884	333	12,744	36,430	72,909
1918	71,592	1,020	6,170	50	10,165	61,287	45,579
1919	139,990	1,725	12,956	872	9,696	40,551	46,762
1920	236,424	7,658	.....	740	6,803	39,667	57,430
1921	144,717	5,878	.....	364	7,112	41,381	19,777

MINERAL AND METALLURGICAL EXPORTS OF FRANCE (*a*) (*k*)

(In metric tons)

Year.	Aluminium.	Antimony.		Arsenic Ore.	Cement.	Coal and Coke.	Copper.		Gold. *Kg.*(*d*)
		Ore.	Metal.				Ore. (*c*)	Metal.	
1904	664	1,191	720	.....	260,686	2,384,928	14,258	12,663	1,537
1905	928	981	815	.....	275,503	(*i*)3,348,010	13,260	13,800	5,740
1906	1,522	3,541	871	.....	329,879	(*i*)1,448,000	8,056	6,130	11,727
1907	1,118	3,460	1,270	13,466	366,624	(*i*)1,224,000	4,151	18,630	6,289
1908	1,332	3,300	2,129	8,600	342,131	(*i*)1,117,000	3,600	17,845	4,455
1909	4,425	4,000	2,408	3,267	316,486	(*i*)1,493,308	6,200	18,775	5,366
1910	4,148	4,583	2,163	2,411	315,020	(*i*)1,580,077	4,163	20,884	7,264
1911	4,058	3,991	1,945	832	333,043	(*i*)1,635,000	8,335	22,690	.....
1912	6,605	1,673	2,890	1,497	361,425	(*i*)2,320,349	6,374	42,307	775
1913	4,514	608	1,808	1,351	398,240	1,304,377	10,154	29,456	394
1914	3,350	128	1,601	1,346	247,444	913,432	5,885	18,546	311
1915	2,946	8	985	.....	130,387	239,905	9,741	4,667	780
1916	2,161	2	2,963	.....	117,711	226,917	755	7,984	683
1917	1,230	1	1,524	.....	64,492	274,214	220	6,692	878
1918	533	1	959	1	33,185	1,955,132	393	4,728	1,050
1919	3,631	154	620	1	73,331	589,830	1,658	8,024	850
1920	2,638	914	1,182	.....	146,621	465,428	1,650	30,264	1,086
1921	604	940	331	.....	136,244	2,192,145	1,516	16,421	425

Year.	Iron.				Lead.		Manganese Ore.
	Ore.	Pig.	Bars.	Steel.	Ore.	Metal.	
1904	1,219,149	191,819	40,374	246,738	1,860	13,467	1,392
1905	1,355,932	218,227	67,240	343,612	3,064	12,903	662
1906	1,759,443	143,142	58,826	236,617	1,354	997	4,103
1907	2,147,000	249,708	84,557	291,434	1,210	1,912	5,167
1908	2,384,000	171,797	86,691	360,509	6,700	1,974	1,000
1909	3,907,338	161,058	96,999	318,925	2,800	2,458	1,149
1310	4,892,542	110,086	122,543	(*k*)302,168	5,855	3,004	722
1911	6,160,100	104,350	171,000	100,000	9,691	2,660	902
1912	8,318,312	216,895	67,000	(*j*)200,085	12,276	1,660	2,282
1913	10,066,628	99,730	.....	(*j*)418,425	14,263	983	1,705
1914	4,828,592	42,755	.....	(*j*)248,130	8,320	816	411
1915	94,864	1,615	.....	(*j*) 9,477	48	581	40
1916	74,561	11,303	.....	(*j*) 26,910	813	6,856	275
1917	126,533	17,433	.....	(*j*) 39,960	405	736	109
1918	68,346	6,999	.....	(*j*) 21,370	122	265	33
1919	1,997,171	129,544	72,915	(*j*)216,195	366	676	1,300
1920	4,839,516	287,252	344,306	(*j*)609,030	2,506	6,389	875
1921	5,297,991	653,209	606,336	(*j*)168,674	3,745	9,698	482

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Year.	Nickel, Refined.	Phosphate Rock.	Plaster.	Pyrite.	Silver. Kg. (c)	Tin (Metal).	Zinc.	
							Ore.	Spelter, Sheets and Scrap.
1904.....	906	78,612	139,551	40,833	23,105	2,300	57,780	19,063
1905.....	1,583	55,240	124,561	21,257	66,904	2,611	72,512	17,802
1906.....	1,088	81,660	142,339	26,216	87,952	601	67,258	19,607
1907.....	1,414	100,508	137,356	24,417	58,199	729	54,316	21,928
1908.....	1,230	71,509	132,924	40,300	56,957	810	57,800	20,589
1909.....	1,940	47,611	120,701	40,200	56,549	886	60,000	24,729
1910.....	2,050	44,384	152,390	56,735	58,294	1,224	56,800	22,975
1911.....	880	31,413	148,952	68,919	17,256	1,520	51,737	25,500
1912.....	1,192	22,062	174,486	43,905	3,856	1,450	60,007	34,124
1913.....	740	21,128	.....	.....	23,524	1,422	58,203	29,733
1914.....	1,103	11,219	.....	.....	35,015	936	21,279	13,549
1915.....	30	1,796	.....	.....	6,298	807	5,600	4,663
1916.....	46	1,727	.....	16,678	2,774	1,374	1,820	4,067
1917.....	36	627	.....	6,993	2,040	403	538	4,164
1918.....	3	36	.....	11,529	2,316	173	439	3,117
1919.....	49	1,517	.....	9,664	12,736	1,178	111	6,415
1920.....	160	3,280	.....	6,678	10,263	1,896	12,038	14,347
1921.....	312	6,016	.....	2,300	40,544	854	8,287	9,415

(*a*) From *L'Economiste Francais* (representing the *Commerce Spécial*), except for 1903-06, inclusive, which are from *Tableau Général du Commerce et de la Navigation*. (*b*) Not reported. (*c*) Includes matte. (*d*) Gold and platinum in sheets, leaves, threads or jewelry, and crude platinum. (*e*) Silver in sheets, leaves, wire, and jewelry. (*f*) Includes bitumen, bituminous schist and sand, and asphaltic limestone. (*g*) Crude and refined. Transposition from hectoliters to tons was performed by assuming specific gravity of petroleum to be 0.9. (*h*) Includes chromate of soda. (*i*) Includes coke. (*j*) Iron and steel other than pig iron. (*k*) From *Statistique de l'Industrie Minérale* in the years 1908, 1909, 1910. Steel in 1910 not classified as before. 1911 and 1914–1918, from *l'Echo des Mines et Métallurgie*. (*l*) Includes bars and steel.

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GERMANY

The mineral production and foreign commerce of the German Empire are given in the following tables in metric tons unless otherwise specified, or in dollars, on the basis of four marks to the dollar. Figures in full-faced type are either provisional figures or estimates.

MINERAL PRODUCTION OF GERMANY (*a*)

Year.	Alum.	Aluminium Sulphate	Arsenic.		Asphaltum.	Boracite.	Cadmium. *Kg.*	Coal.	
			In Ore.	Salts.				Bituminous.	Lignitic.
1906	4,494	55,969	6,249	3,052	117,413	161	21,486	137,117,926	56,419,567
1907	4,200	59,473	4,878	2,904	126,649	114	32,949	143,185,691	62,546,671
1908	3,802	53,958	6,065	2,822	89,009	128	32,995	147,671,149	67,615,200
1909	4,179	56,096	6,150	2,911	77,537	149	37,187	148,788,050	68,657,606
1910	4,406	58,349	6,151	3,066	81,208	167	41,100	152,827,777	69,473,883
1911	3,076	.....	4,859	2,981	81,902	160	42,000	160,747,580	73,760,867
1912	.....	.....	4,869	.....	96,117	224	43,000	174,875,297	80,934,797
1913	.....	.....	5,700	.....	105,500	203	.....	190,109,400	87,233,100
1914	.....	.....	4,700	.....	81,800	.....	.....	161,384,700	83,693,600
1915	.....	.....	4,100	.....	32,400	.....	.....	146,867,600	87,948,400
1916	.....	.....	3,600	.....	31,500	.....	.....	159,169,700	94,180,500
1917	.....	.....	5,600	.....	12,300	136	.....	167,747,200	95,542,900
1918	.....	.....	4,401	.....	7,980	.....	.....	158,254,116	100,599,318
1919	.....	.....	2,098	.....	12,554	103	38,000	116,707,234	93,648,264

Year.	Cobalt, Nickel, and Bismuth Ores.	Copper.				Gold.	Graphite.
		Ore.	Matte. (*b*)	Ingots.	Sulphate.		
1906	.....	768,523	771	32,275	6,757	$2,931,750	4,055
1907	2,809	771,227	527	31,946	5,284	3,111,379	4,033
1908	8,535	727,384	328	30,001	7,117	3,162,544	4,844
1909	10,388	798,618	2,242	31,126	6,211	3,366,986	6,774
1910	10,313	925,957	3,735	34,926	5,210	3,227,250	7,415
1911	.....	868,600	1,142	37,452	7,353	3,302,300	11,298
1912	12,861	969,330	2,574	49,447	5,955	3,322,700	12,532
1913	.....	886,000	4,100	49,400	6,000	25,717,698	12,100
1914	.....	832,500	4,800	46,200	4,500	15,217,966	13,600
1915	.....	968,000	3,500	58,900	2,900	4,120,148	16,900
1916	.....	1,217,100	3,000	79,800	5,500	7,906,573	30,600
1917	.....	1,132,700	5,000	74,000	6,200	7,400,159	37,500
1918	.....	.....	.....	32,357	.....	.....	40,996
1919	123,299	616,809	1,865	34,822	.....	8,796,856	30,525

Year.	Iron and Steel.				Lead.		
	Iron Ore.	Pig Iron. (*c*)	Wrought Iron and Steel.	Sulphate. (*d*)	Ore.	Pig.	Litharge.
1906	26,734,570	12,292,819	11,307,807	13,376	140,914	150,741	4,137
1907	27,697,127	12,875,159	12,063,632	14,033	147,272	142,271	4,325
1908	24,278,151	11,805,321	10,930,933	15,738	156,861	164,079	5,339
1909	25,505,409	12,917,653	11,719,239	21,838	159,852	167,920	3,059
1910	28,709,700	14,502,183	12,988,177	18,677	148,497	159,851	3,581
1911	29,879,361	15,280,527	14,384,271	17,002	140,154	161,287	3,667
1912	27,199,944	15,220,881	16,508,987	.....	142,839	192,618	4,135
1913	28,607,900	16,763,800	20,419,300	.....	144,900	205,400	.....
1914	20,505,300	12,581,200	16,346,800	.....	129,000	198,400	2,600
1915	17,709,600	10,154,700	14,230,100	.....	119,600	134,700	800
1916	21,333,700	11,342,100	13,284,738	.....	137,200	120,400	400
1917	22,464,800	11,707,100	13,142,247	.....	124,600	98,200	100
1918	7,914,897	11,758,967	14,875,753	.....	.....	68,900	.....
1919	6,142,359	5,604,408	.....	.....	.....	67,695	350

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Year.	Magnesium Salts.		Manganese Ore.	Petroleum.	Potassium Salts.				
	Chloride.	Sulphate.			Chloride.	Kainite. (f)	Sulphate.	Potassium-Magnesium Sulphate.	Other than Kainite.
1906 ...	38,468	43,041	52,485	81,350	403,387	2,720,594	54,490	35,211	2,821,073
1907 ...	32,891	41,105	73,105	106,379	473,138	2,624,412	60,292	33,368	3,124,955
1908 ...	29,775	42,977	67,692	141,900	511,258	2,715,487	55,756	33,149	3,383,535
1909 ...	31,526	53,812	77,177	143,244	624,994	3,181,349	68,539	38,722	3,969,554
1910 ...	32,207	57,314	80,560	145,168	741,259	4,249,667	84,583	37,438	4,062,004
1911 ...	36,764	55,179	87,297	142,992	838,420	4,425,497	107,631	42,253	5,181,379
1912 ...	85,387	99,442	185	134,986	506,744	5,889,238	123,407	54,435	.....
1913 ...	.....	.....	748	121,000	495,625	.....	121,529	62,945	.....
1914 ...	.....	.....	.....	110,300	.....	.....	.....	.....	.....
1915 ...	.....	.....	939	99,300	.....	.....	.....	.....	.....
1916 ...	.....	.....	298	92,700	.....	.....	.....	.....	.....
1917 ...	.....	.....	1,017	90,600	.....	.....	.....	.....	.....
1918 ...	.....	.....	.....	186,000	.....	.....	.....	.....	.....
1919 ...	.....	.....	11,475	37,516	.....	4,610,423	.....	.....	3,277,729

Year.	Pyrite.	Salt.		Silver and Gold Ore.	Silver. *Kg.*	Sodium Sulphate.	Sulphur.	Sulphuric Acid.
		Rock.	Evaporated.					
1906....	196,971	1,235,041	635,171	8,066	393,442	81,175	178	1,335,128
1907....	196,351	1,285,137	665,547	8,280	386,933	80,347	176	1,402,398
1908....	219,456	1,331,934	665,651	7,653	407,185	72,667	811	1,391,653
1909....	198,688	1,370,668	647,939	7,510	400,562	71,813	1,185	1,434,709
1910....	215,708	1,424,084	669,120	6,646	420,008	84,787	1,272	1,616,336
1911....	217,459	1,436,492	645,991	4,890	439,580	82,664	1,251	1,534,455
1912....	242,121	1,352,524	671,622	595	.....	.....	.....	1,649,681
1913....	268,600	675,900	.....	*Nil.*	765,800	.....	.....	1,727,400
1914....	232,300	643,400	.....	*Nil.*	651,100	.....	.....	1,505,700
1915....	441,600	581,800	.....	*Nil.*	349,400	.....	.....	1,137,900
1916....	635,700	596,300	.....	.....	319,000	.....	.....	1,019,000
1917....	803,700	511,300	.....	.....	276,100	.....	.....	1,104,300
1918....	804,738	.....	.....	.....	.....	.....	.....	.....
1919....	381,384	1,487,849	291,719	.....	311,527	.....	.....	.....

Year.	Tin.			Uranium and Tungsten Ores.	Zinc.		
	Ore.	Block.	Chloride.		Ore.	Spelter.	Sulphate.
1906	.....	6,597	987	.....	704,590	205,691	6,092
1907	.....	5,838	1,812	3	698,425	208,195	5,145
1908	111	6,374	2,266	42	706,441	216,490	5,310
1909	124	8,994	3,247	98	723,565	219,766	5,574
1910	125	11,395	3,391	95	718,316	221,395	6,208
1911	.....	12,412	3,749	.....	699,970	235,776	6,703
1912	(i)	10,646	3,094	70	643,598	269,161	6,413
1913	.....	12,000	.....	.....	646,300	278,800	.....
1914	.....	9,800	.....	.....	533,200	236,000	.....
1915	.....	1,100	.....	.....	488,500	185,300	.....
1916	.....	1,000	.....	.....	527,000	178,100	.....
1917	.....	1,800	.....	.....	527,100	186,800	.....
1918	.....	.....	.....	.....	17,031,413	232,000	.....
1919	.....	799	.....	20,583	.....	97,404	.....

(a) From the *Vierteljahrshefte zur Statistik des Deutschen Reichs.* Where gold is reported, 1 mark = $0.238. (b) Includes black copper. (c) Includes ferromanganese and spiegeleisen. (d) Contains a small quantity of copper and iron sulphate mixed. (f) Compound of potassium chloride and magnesium sulphate. (i) Included with cobalt, nickel and bismuth.

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MINERAL PRODUCTION OF BADEN (a)
(In metric tons or dollars; 4 marks = $1)

Year.	Aluminium Sulphate.	Barytes.	Coal.	Gypsum.	Manufactures of Iron.		
					Cast, Foundry.	Steel.	Wrought.
1899....	2,153	2,430	4,700	29,419	53,608	3,830	1,402
1900....	2,286	2,970	4,930	26,381	50,102	3,532	1,364
1901....	2,260	3,991	3,650	28,183	40,100	8,739	1,158
1902....	2,374	6,234	2,078	33,150	40,973	12,663	1,052
1903....	2,498	8,857	1,990	29,423	45,233	7,666	863
1904....	2,392	9,078	1,485	26,984	64,320	7,687	783
1905....	2,581	11,094	668	28,823	74,128	8,053	842
1906....	2,583	11,984	1,000	25,643	81,387	11,068	466
1907....	2,644	9,303	2,075	29,153	98,430	10,818	533
1908....	2,524	(c) 8,554	2,473	35,217	83,724	10,430	602
1909....	2,329	(c) 15,186	2,356	36,621	83,458	11,643	484
1910....	2,141	(c) 13,832	1,650	41,078	95,795	12,134	239
1911....	2,554	15,014	(b)	42,408	107,784	11,909	244
1912....	.....	15,871	.....	51,778	.....	.....	.....
1913....	.....	16,445	.....	49,767	.....	.....	.....

Year.	Lead Ores.	Salt.	Sulphuric Acid.	Tripoli.	Zinc Ore.
1899.....	(b)	31,197	13,660	12	357
1900.....	67	32,699	15,938	9	3,004
1901.....	369	32,835	17,081	8	2,870
1902.....	450	32,192	19,265	11	2,958
1903.....	350	32,383	19,755	11	3,171
1904.....	265	32,148	35,517	12	5,063
1905.....	264	31,393	40,761	12	4,046
1906.....	246	31,288	38,655	15	1,466
1907.....	278	32,078	42,831	25	2,198
1908.....	329	33,993	41,455	13	2,793
1909.....	372	34,040	42,219	14	3,253
1910.....	419	32,729	56,069	7	3,345
1911.....	191	32,118	47,796	14	3,067
1912.....	428	32,326	.....	14	3,730
1913.....	480	33,502	.....	13	3,882

(a) From the *Uebersicht der Production des Bergwerks-, Hütten-, und Salinen-Betriebes in dem Badischen Staate.* (b) Not reported. (c) Includes fluorspar.

MINERAL PRODUCTION OF BAVARIA (a)
(In metric tons; 4 marks = $1)

Year.	Barytes.	Kaolin.	Coal.	Coal (Lignite).	Copperas and Other Sulphate.	Emery.	Feldspar.	Fluor-spar.	Graphite.
1902..	8,034	92,073	1,233,558	27,337	691	225	447	5,460	5,023
1903..	8,642	88,140	1,356,556	25,139	814	220	1,060	3,410	3,719
1904..	9,411	95,160	1,341,925	53,517	893	265	1,866	4,770	3,784
1905..	10,030	99,910	1,317,951	154,128	844	255	1,710	4,413	4,921
1906..	19,817	98,138	1,381,175	140,290	836	320	1,740	5,570	4,055
1907..	21,500	115,387	1,495,895	286,256	850	326	2,125	4,780	4,033
1908..	17,195	68,551	647,639	1,209,110	910	245	5,859	5,480	4,844
1909..	17,920	187,312	694,191	1,242,088	1,094	305	3,151	5,580	6,774
1910..	24,711	107,660	713,994	1,299,970	1,333	270	2,620	5,132	7,415
1911..	26,234	70,512	763,172	1,548,465	.....	210	3,165	4,680	11,298
1912..	27,199	72,517	790,680	1,704,654	.....	260	6,666	4,220	12,532
1913..	.....	.....	811,000	1,895,000	.....	.....	.....	.....	.....
1919..	8,804	128,424	603,790	2,046,992	.....	6,527	6,398	30,451	
1920..	7,888	194,485	92,178	2,437,633	.....	140	5,850	6,272	20,447

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Year.	Gypsum.	Iron.						Lithographic Limestone.
		Ore.	Bar.	Cast, 1st Fusion.	Cast, 2d Fusion.	Pig.	Steel.	
1902....	31,701	157,375	38,429	56	81,874	83,123	115,354	.....
1903....	30,894	162,500	36,853	41	89,804	90,168	127,141	9,890
1904....	22,766	180,342	37,780	40	108,025	92,200	125,483	13,336
1905....	46,247	182,389	36,459	24	112,875	94,242	134,755	11,360
1906....	50,763	203,596	38,508	.....	122,115	97,812	150,129	.....
1907....	48,975	277,280	36,883	*Nil.*	138,659	98,143	150,148	11,590
1908....	51,314	278,681	30,740	*Nil.*	128,234	131,404	176,085	9,858
1909....	51,630	279,514	33,448	*Nil.*	130,129	134,133	219,606	9,420
1910....	54,397	303,844	30,881	*Nil.*	148,261	133,679	249,198	9,790
1911....	60,390	375,409	165,683	*Nil.*	171,976	.....	339,401	8,175
1912....	57,114	450,074	(c)	.....	396,656	195,606	998,624	9,903
.....	.....	.....	.....	.....	.....	.....	.....	.....
1919....	33,700	376,486	.....	.....	.....	159,690	.....	3,282
1920....	48,580	451,826	.....	.....	.....	161,797	.....	1,878

Year.	Marl. (For Cement)	Mineral Paint and Chalk.	Pyrites.	Rock Salt.	Soapstone.	Sodium Sulphate.	Sulphuric Acid.
1902....	178,301	13,947	2,635	832	.....	.....	.....
1903....	200,407	19,486	2,324	879	1,866	.....	.....
1904....	170,698	19,107	3,427	1,139	1,709	.....	.....
1905....	231,310	18,285	3,301	911	1,872	.....	.....
1906....	230,271	22,304	3,918	1,053	.....	.....	.....
1907....	230,583	21,219	5,085	1,393	1,999	1,439	161,868
1908....	307,820	21,310	4,037	1,285	2,199	1,743	149,079
1909....	276,974	21,692	2,952	1,860	2,329	1,265	178,371
1910....	273,727	22,357	4,466	1,192	3,083	1,416	171,131
1911....	265,899	24,258	6,316	782	3,431	2,061	170,039
1912....	341,068	30,033	6,531	1,162	3,221	.....	254,708
.....	.....	.....	.....	.....	.....	.....	.....
1919....	98,639	18,414	7,396	445	5,371	.....	.....
1920....	32,097	37,069	7,771	306	20,943	.....	.....

(a) From the *Uebersicht der Production des Bergwerks-, Hütten-, und Salinen-Betriebes in dem Bayerischen Staate.* (b) Not reported. (c) With cast iron.

MINERAL PRODUCTION OF PRUSSIA (a)

(Metric tons; 4 marks = $1)

Year.	Alum Shale.	Antimony and Alloys.	Arsenic Products.	Arsenic Ore.	Asphalt.	Boracite.	Cadmium. Kg.	Coal.
1904....	106	2,774	1,573	3,527	26,348	115	25,245	112,955,621
1905....	97	2,795	1,493	4,022	28,872	151	24,568	113,000,657
1906....	634	2,953	1,551	5,430	32,270	124	21,456	128,295,948
1907....	154	3,515	1,591	4,224	39,243	90	32,949	134,044,060
1908....	80	3,596	1,646	5,015	27,444	105	32,995	139,002,378
1909....	60	3,841	1,849	5,731	19,509	123	37,187	139,906,194
1910....	46	4,969	2,068	5,789	21,595	138	41,058	143,771,612
1911....	63	5,411	1,862	4,476	19,956	147	42,575	151,324,080
1912....	104	.....	.....	4,870	21,241	186	.....	165,302,784
1913....	180	.....	.....	5,008	17,795	160	.....	179,861,015
.....	.....	.....	.....	.....	.....	.....	.....	.....
1918....	.....	.....	.....	10,558	.....	.....	.....	152,809,966
1919....	.....	.....	.....	5,117	.....	66	.....	112,028,796
1920....	.....	.....	.....	6,009	.....	89	.....	127,036,799

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Year.	Coal (Lignite).	Cobalt Ore.	Cobalt Products.	Copper.	Copper and Iron Sulphate.	Copper Ore.	Copper Matte.
1904....	41,153,576	41	85	27,450	95	782,049	601
1905....	44,148,751	22	99	28,874	102	769,381	1,052
1906....	47,912,721	7	98	29,166	94	755,812	525
1907....	52,660,597	*Nil.*	109	28,945	64	755,203	499
1908....	55,456,860	*Nil.*	100	27,301	50	711,921	296
1909....	56,029,554	*Nil.*	93	28,523	55	798,448	1,935
1910....	56,644,291	*Nil.*	94	30,244	44	914,519	2,060
1911....	60,531,943	*Nil.*	107	30,986	27	919,827	996
1912....	65,803,959	*Nil.*	.....	.....	.....	967,785	.....
1913....	70,051,871	*Nil.*	.....	.....	.....	941,402	.....
.....	.....	.....	.....	.....	.....	.....	.....
1918....	83,372,828	.....	.....	.....	.....	1,004,050	.....
1919....	75,953,982	.....	.....	.....	.....	615,808	.....
1920....	91,969,783	.....	.....	.....	.....	574,201	.....

Year.	Copper Sulphate.	Epsom Salt.	Gold. *Kg.*	Iron.	Iron Ore.	Iron Sulphate.	Lead.
1904.....	3,364	289	1,081.9	6,573,507	3,757,651	12,524	128,294
1905.....	3,065	338	1,034.9	7,106,975	4,130,210	12,075	143,270
1906.....	2,724	144	750.2	8,154,880	4,713,928	12,473	140,690
1907.....	2,129	263	771.0	8,266,300	5,077,773	13,014	132,366
1908.....	3,116	398	786.6	7,989,260	4,311,593	14,062	153,541
1909.....	2,500	395	588.2	8,410,824	4,389,950	18,295	156,533
1910.....	1,749	162	566.3	9,995,012	4,823,606	16,119	146,993
1911.....	2,464	114	520.	10,477,263	4,948,711	15,468	147,538
1912.....	.....	.....	.....	.....	5,331,240	.....	.....
1913.....	.....	.....	.....	.....	5,461,670	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....
1918.....	.....	.....	.....	.....	6,203,399	.....	.....
1919.....	.....	.....	.....	.....	4,625,905	.....	.....
1920.....	.....	.....	.....	.....	4,530,978	.....	.....

Year.	Lead Ore.	Litharge.	Manganese Ore.	Nickel.	Nickel Ore.	Nickel Sulphate.	Ocher and Mineral Paints.
1904.....	150,328	2,517	52,092	2,333	13,518	207	3,200
1905.....	138,928	2,272	51,048	2,631	10,432	220	3,170
1906.....	127,322	2,744	51,881	2,648	7,472	187	3,635
1907.....	133,528	2,959	72,442	2,093	7,557	189	3,707
1908.....	141,316	4,190	67,241	2,622	8,238	181	3,183
1909.....	158,811	2,365	76,741	3,186	10,095	163	3,435
1910.....	146,830	3,076	80,325	3,497	10,053	213	142
1911.....	135,366	3,441	86,902	3,744	9,609	244	.....
1912.....	140,158	.....	92,474	.....	12,091	.....	.....
1913.....	143,799	.....	(b)	.....	13,565	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....
1918.....	123,548	.....	1,034	.....	93,555	.....	.....
1919.....	99,230	.....	553	.....	29,151	.....	.....
1920.....	91,377	.....	766	.....	16,050	.....	.....

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Year.	Petroleum.	Potassium Salts.		Pyrite.	Quicksilver. *Kg.*	Salt.	
		Kainite.	All Other.			Common.	Rock.
1904.....	67,604	1,261,930	1,447,323	163,209	3,030	328,933	394,910
1905.....	57,741	1,580,530	1,734,033	174,641	2,597	328,051	436,942
1906.....	59,196	1,923,088	1,937,181	186,849	5,084	339,675	492,339
1907.....	80,255	1,839,409	2,070,978	184,962	5,080	353,290	480,563
1908.....	113,002	2,037,203	2,192,188	204,992	4,423	359,003	478,346
1909.....	113,518	2,431,401	2,436,319	189,773	5,213	344,685	491,071
1910.....	110,996	3,119,400	2,584,565	203,596	4,492	351,698	500,978
1911.....	98,611	3,502,782	2,920,725	203,249	2,861	337,583	527,034
1912.....	87,443	4,256,476	3,287,177	233,397	.....	343,883	527,275
1913.....	71,178	4,426,054	3,658,109	228,408	.....	353,260	526,218
.....	.....	.....	.....	.....	.....	.....	.....
1918.....	38,029	3,928,003	2,682,839	817,883	.....	209,172	1,278,157
1919.....	37,353	3,372,753	2,027,375	348,585	.....	142,471	780,923
1920.....	34,955	4,171,890	3,498,593	398,426	.....	167,918	1,476,228

Year.	Silver. *Kg.*	Silver and Gold Ores.	Sulphur.	Sulphuric Acid.	Tin.	Zinc.		
						Ore.	Metal.	Sulphate.
1904.....	252,020	8	16	868,424	4,193	710,599	192,903	3,696
1905.....	266,072	4	14	921,219	5,196	727,104	198,179	3,506
1906.....	264,427	239	16	980,188	6,570	702,933	205,632	3,630
1907.....	249,348	34	7	1,004,599	5,819	696,039	207,849	3,057
1908.....	274,154	7	706	997,931	5,330	703,394	212,991	3,223
1909.....	271,779	2	1,096	1,006,787	8,943	720,139	214,551	3,434
1910.....	277,777	0.2	1,239	1,164,015	11,345	714,855	216,362	3,875
1911.....	277,981	.....	1,239	1,219,879	12,335	696,903	230,995	4,127
1912.....	.....	.....	.....	.....	.....	647,081	.....	.....
1913.....	.....	.....	.....	.....	.....	649,695	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....
1918.....	.....	.....	.....	.....	.....	488,640	.....	.....
1919.....	.....	.....	.....	.....	.....	313,347	.....	.....
1920.....	.....	.....	.....	.....	.....	316,658	.....	.....

(*a*) From *Zeitschrift für das Berg, Hütten, und Salinenwesen.*
(*b*) Included in "Iron Ore."

MINERAL IMPORTS OF GERMANY (*a*)

Year.	Aluminium Refined and Crude.	Ammonium Sulphate.	Antimony.	Antimony and Arsenic Ores.	Asbestos, Crude.	Asphalt.	Bituminous Rock.	Barium Chloride.	Barytes. (*b*)
1903 ...	1,155	35,168	2,281	1,741	5,727	94,377	40,873	2,374	5,534
1904 ...	2,422	35,166	2,003	1,687	5,251	85,049	38,812	2,428	6,742
1905 ...	3,252	48,005	1,680	567	7,830	3,461	64,196	2,114	7,981
1906 ...	3,886	35,366	2,044	2,417	9,828	15,095	118,238	2,559	17,246
1907 ...	3,974	33,522	2,496	4,913	11,096	4,793	128,257	2,781	12,588
1908 ...	3,204	47,265	2,670	2,073	10,034	2,587	130,063	2,256	19,969
1909 ...	8,696	58,132	2,719	2,912	11,928	1,209	98,378	1,907	14,560
1910 ...	9,892	31,400	2,982	3,347	11,729	2,932	117,763	1,955	5,782
1911 ...	10,454	24,463	3,607	6,429	12,334	133,635	17,476	2,002	7,926
1912 ...	18,112	23,098	3,400	2,891	14,790	147,784	18,409	3,674	18,666
1913 ...	15,508	34,627	3,604	3,700	14,658	145,351	.....	2,598	19,466
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1920...	7,913	142	1,371	1,378	6,830	1,801	4,435	920	360

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Year.	Borax.	Bauxite.	Calcium Carbide.	Cement.	Chalk (*d*), Crude White.	Chrome Ore.	Coal.		Coke.
							Bitum., Arthracite, Cannel.	Lignitic.	
1903 ...	2,567	22,316	14,081	49,870	(*d*)33,362	13,919	6,766,513	7,962,123	432,819
1904 ...	2,603	27,849	14,840	60,188	(*d*)32,581	18,132	7,299,042	7,669,099	550,302
1905 ...	2,802	39,137	17,256	148,118	(*d*)35,529	11,998	9,399,693	7,945,261	713,610
1906 ...	3,044	43,177	22,819	233,119	18,871	17,124	9,253,711	8,430,441	565,561
1907 ...	2,014	59,989	25,834	241,475	16,035	19,508	13,729,849	8,963,103	584,220
1908 ...	1,903	48,064	29,024	168,504	17,606	16,974	11,661,503	8,581,966	575,091
1909 ...	2,550	45,543	26,956	224,178	15,924	22,018	12,198,634	8,166,479	673,012
1910 ...	3,181	56,287	30,712	242,663	17,700	24,470	11,195,593	7,397,719	622,452
1911 ...	5,358	37,155	36,994	253,023	23,717	16,022	10,913,948	7,069,064	598,958
1912 ...	7,978	36,348	47,984	228,896	28,031	23,201	10,380,482	7,266,116	589,713
1913 ...	7,381	38,452	46,725	168,449	32,546	23,251	10,540,018	6,986,681	592,661
1920 ...	2,256	13,740	(*e*)7,103	58,920	11,247	10,371	362,937	2,340,696	2,129

Year.	Peat and Peat Coke.	Briquettes.	Cobalt and Nickel Ore.	Copper.				Copperas	Cryolite.
				Ore. and Matte.	Ingots.	Bars, Wire and Sheets.	Sulphate.		
1903 ...	14,640	84,635	36,927	13,714	83,261	568	1,735	778	1,082
1904 ...	9,071	125,477	14,555	7,949	110,231	719	2,180	765	1,139
1905 ...	11,439	191,753	39,590	10,137	102,218	927	1,702	666	1,143
1906 ...	19,428	162,650	22,557	9,941	126,071	409	4,519	621	(*k*)
1907 ...	15,238	195,403	29,296	19,295	124,116	772	5,078	1,165	(*k*)
1908 ...	15,266	192,391	17,402	17,456	157,669	952	6,550	7,234	(*k*)
1909 ...	13,208	211,058	10,186	26,488	154,673	416	3,952	5,954	(*k*)
1910 ...	16,188	241,267	9,937	22,194	181,551	403	4,145	4,336	(*k*)
1911 ...	14,517	210,933	14,897	23,327	191,590	520	7,074	3,323	(*k*)
1912 ...	11,040	187,736	14,987	23,192	200,608	332	3,869	5,925	(*k*)
1913 ...	11,796	147,416	13,658	27,594	225,392	.....	.....	2,954	(*k*)
1920 ...	8,169	41,280	3,067	108,311	59,522	1,973	96	44	(*k*)

Year.	Gold, Silver and Platinum Ores.	Graphite	Gypsum.	Iodine.	Iron.		Lead.		
					Ore.	Pig.	Ore.	Pig and Scrap.	Lead White.
1903 ...	4,386	20,953	8,328	320	5,225,336	158,347	67,573	52,440	442
1904 ...	5,960	23,533	9,550	272	6,061,127	178,256	83,807	61,388	622
1905 ...	6,225	26,143	11,247	377	6,085,196	158,700	92,667	78,528	2,488
1906 ...	4,819	28,175	11,062	297	7,629,730	409,083	90,027	71,191	2,342
1907 ...	3,601	29,405	14,662	147	8,476,076	443,624	137,861	75,200	3,037
1908 ...	1,922	34,491	14,599	194	7,732,949	252,779	133,597	77,218	3,558
1909 ...	1,759	29,191	11,285	369	8,366,599	134,230	111,017	76,930	2,890
1910 ...	2,552	30,733	10,873	363	9,816,822	136,330	112,151	81,541	2,780
1911 ...	2,947	32,812	11,978	303	10,812,595	129,850	143,598	100,515	3,928
1912 ...	2,200	37,633	10,628	260	12,120,090	135,722	122,847	93,585	2,709
1913 ...	1,932	37,168	8,818	258	14,019,045	124,236	142,977	83,781	1,980
1920 ...	36	17,101	4,166	24	6,450,421	97,999	7,674	17,307	74

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Year.	Magnesite.	Manganese Ore.	Mineral Pigments.	Nickel.	Ozokerite.	Petroleum Products		Phosphorus.
						Illuminating Oil.	Lubricating Oil.	
1903....	14,958	204,647	9,888	1,507	1,663	1,067,697	147,837	222
1904....	15,877	223,709	10,494	1,712	1,300	1,076,324	142,929	220
1905....	19,459	255,760	11,473	1,955	1,114	1,070,252	143,926	198
1906....	25,527	262,311	3,960	3,478	1,303	984,134	180,989	208
1907....	30,857	331,171	2,166	2,182	1,653	1,115,205	226,609	165
1908....	28,305	393,327	1,635	3,058	1,447	1,123,632	216,857	141
1909....	29,994	334,133	13,804	3,745	1,447	1,085,839	216,987	179
1910....	40,218	384,445	15,100	4,606	1,729	1,135,886	230,516	169
1911....	47,930	487,872	15,703	2,598	1,591	955,482	260,242	200
1912....	69,064	420,709	17,874	2,027	1,479	795,011	241,030	205
1913....	64,974	680,371	18,971	3,315	1,363	745,466	248,035	209
1920....	44,562	(j)	1,967	886	97	214,091	163,347	20

Year.	Phosphate Rock.	Potassium Salts.							Pumice Stone. (g)	Pyrite.
		Chloride.	Cyanide. (f)	Iodide.	Nitrate.	Carbonate.	Hydroxide.	Sulphate.		
1903....	461,092	40	3	8	2,163	1,850	52	81	2,697	519,317
1904....	508,634	47	2	10	2,349	1,955	61	121	3,000	503,503
1905....	501,048	223	3	30	2,156	1,693	24	131	3,240	552,184
1906....	531,195	181	3	18	1,918	2,099	44	257	5,463	579,355
1907....	579,505	1,615	1	8	1,815	2,304	92	141	5,443	742,526
1908....	736,127	49	4	7	2,200	1,773	50	169	6,154	659,871
1909....	663,400	55	2	4	2,853	1,750	64	101	6,639	691,213
1910....	723,271	72	2	8	1,979	2,366	63	66	7,446	792,735
1911....	831,027	1,160	33	13	2,114	2,616	67	61	9,659	862,214
1912....	902,844	46	5	11	597	2,321	62	44	8,365	1,073,285
1913....	928,798	15	3	13	402	2,760	42	44	8,801	1,023,952
1920....	133,368	223	6	1	1	26	188	16	588	478,510

Year.	Quicksilver.	Salt.	Slag and Slag Wool.	Sodium Salts.			Strontianite. (n)
				Soda, Calcined.	Nitrate (Chile Saltpeter).	Sulphate and Sulphite.	
1903	674	20,118	877,394	114	467,130	6,058	24,183
1904	691	18,743	846,738	179	506,172	9,598	18,055
1905	729	20,726	888,665	143	540,916	4,752	13,720
1906	698	16,997	813,388	189	593,218	7,405	5,212
1907	831	23,109	568,046	257	591,131	10,446	5,595
1908.	648	24,975	562,853	293	604,457	4,404	4,211
1909	723	19,319	492,771	181	665,450	9,214	4,277
1910	836	30,443	766,320	105	749,945	9,302	4,552
1911	919	29,067	685,943	559	730,939	5,976	8,251
1912	990	17,887	1,248,693	1,987	812,898	5,609	4,259
1913	961	21,422	.....	2,633	774,298	10,074	3,965
1920	404	1,603	.....	14,962	31,359	6,568	.....

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Year.	Sulphur.	Sulphuric Acid.	Super-phosphate.	Tin, Crude.	Zinc.			
					Ore.	Spelter.	Drawn or Rolled.	Zinc White, Zinc Gray, Lithophone.
1903....	41,545	13,418	82,740	13,925	67,156	25,749	237	4,667
1904....	41,030	16,087	91,288	14,352	93,515	26,389	151	6,461
1905....	39,989	33,837	109,666	13,501	126,577	29,583	54	7,802
1906....	41,390	74,536	76,384	14,098	178,953	39,314	97	9,140
1907....	44,700	59,753	62,877	12,814	184,703	28,459	134	10,139
1908....	44,066	61,391	71,879	14,039	199,340	32,622	286	7,080
1909....	42,941	74,384	80,512	13,537	201,110	44,514	99	7,002
1910....	46,796	86,743	78,873	14,297	240,584	39,328	246	9,239
1911....	46,054	99,653	71,119	14,500	262,399	48,355	467	7,697
1912....	42,284	98,573	62,400	15,550	293,090	56,937	1,003	9,367
1913....	46,737	130,257	53,193	14,261	313,269	57,641	725	9,108
1920....	23,588	19,084	25,239	4,536	28,850	527	76	308

MINERAL EXPORTS OF GERMANY (a)

Year.	Aluminium Refined and Crude.	Aluminium Wares, etc.	Aluminium Sulphate.	Ammonium.		Antimony and Arsenic Ores.	Antimony.	
				Carbonate and Chloride.	Sulphate.		Metallic.	Salts.
1903....	353	2,865	28,513	2,778	5,592	427	83	873
1904....	407	3,077	29,311	3,106	10,696	486	250	964
1905....	1,192	3,476	34,776	3,579	27,589	287	218	1,097
1906....	1,111	1,321	25,937	3,555	37,288	548	221	997
1907....	1,119	1,142	24,759	3,118	57,439	930	255	1,168
1908....	590	642	22,376	1,161	73,186	588	146	1,030
1909....	492	1,273	58,723	1,093	58,722	577	160	1,090
1910....	616	1,755	93,069	1,500	93,069	571	198	1,047
1911....	768	1,331	30,107	4,895	74,410	612	298	1,206
1912....	2,074	4,184	32,469	5,292	57,268	569	132	1,155
1913....	2,703	5,667	31,772	5,401	75,868	502	702	1,461
1920....	2,864	5,542	34,572	.....	26,094	72	32	335

Year.	Arsenic.		Asbestos.	Barytes. (b)	Barium.		Bauxite. (c)	Borax.	Bromine.
	Metallic.	White, etc.	Crude.		Chloride and Salts of.	White.			
1903 ...	32	1,903	513	72,455	8,417	3,187	19	2,779	155
1904 ...	50	1,956	738	69,564	8,596	3,777	21	2,741	208
1905 ...	40	1,753	1,173	81,134	9,550	4,382	6	2,720	156
1906 ...	.....	2,282	1,938	90,819	6,541	10,721	398	2,795	172
1907 ...	(m)45	1,733	1,707	111,209	4,189	8,454	517	3,049	118
1908 ...	(m)65	1,956	1,345	91,111	3,389	5,190	783	2,379	227
1909 ...	(m)54	1,012	1,740	90,555	5,340	4,888	1,116	2,735	206
1910 ...	(m)57	1,507	1,537	114,264	6,403	5,528	863	2,916	225
1911 ...	(m)71	1,973	1,503	128,452	6,180	6,834	960	3,199	229
1912 ...	(m)73	2,400	1,891	142,957	7,389	8,298	400	3,330	187
1913 ...	.....	2,612	1,461	158,065	5,649	7,647	355	3,433	239
1920 ...	(m)57	2,583	209	92,273	1,218	3,033	14,691	138	(o)

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Year.	Bromine Salts.	Calcium.		Cement.	Chalk, Crude White.	Chromium.		Coal.	
		Carbide.	Chloride.			Ore.	Alum.	Bituminous, Anthracite and Cannel.	Lignitic
1903	435	335	1,831	742,381	(d)12,211	37	1,921	17,389,934	22,499
1904	411	608	2,381	635,248	(d)11,359	47	2,432	17,996,726	22,135
1905	634	709	2,831	675,664	(d)13,031	43	2,507	18,156,998	20,118
1906	643	545	(l)	736,579	4,287	(h) 36	2,942	19,550,964	18,759
1907	655	918	(l)	692,982	2,919	(h) 149	3,110	20,056,503	22,065
1908	506	844	(l)	528,847	2,108	(h) 110	3,215	21,190,777	27,377
1909	486	968	(l)	611,893	4,395	(h)5,023	3,023	23,350,705	39,815
1910	323	1,482	(l)	725,356	3,359	(h) 386	3,998	24,257,651	62,441
1911	.....	2,120	(l)	845,850	1,537	(h)1,795	2,815	27,412,218	58,071
1912	372	971	(l)	1,056,622	2,890	(h) 778	3,221	31,145,057	56,966
1913	405	.....	(l)	1,129,563	3,409	(h) 681	3,313	34,573,514	60,345
1920	(p)869	3,266	9,830	139,247	471	(h) 70	659	7,304,982	72,299

Year.	Coke.	Peat and Peat Coke.	Briquets.	Cobalt and Nickel Ore.	Copper.			
					Ore and Matte.	Bars, Sheets and Wire.	Ingots.	Sulphate.
1903	2,523,351	16,986	895,145	1	15,986	10,715	4,333	1,880
1904	2,716,855	14,830	917,526	83	19,235	12,594	4,223	2,231
1905	2,761,080	16,009	936,694	107	28,908	10,006	5,958	2,180
1906	3,415,347	15,680	1,095,029	(i)	6,414	10,728	7,241	3,018
1907	3,792,580	25,746	1,260,135	(i)	20,950	13,411	6,113	2,016
1908	3,577,496	26,817	1,493,054	(i)	21,729	17,209	6,868	2,994
1909	3,444,791	23,579	1,620,460	(i)	22,437	15,395	6,495	1,290
1910	4,125,898	20,360	1,988,177	(i)	23,751	19,351	7,654	2,108
1911	4,555,477	35,855	2,477,492	(i)	27,396	19,669	7,106	3,346
1912	5,850,350	60,557	2,746,536	(i)	21,514	20,245	7,854	3,812
1913	6,411,418	86,920	3,163,742	(i)	25,221	.....	7,208	4,013
1920	981,400	27,726	381,084	.....	2,904	4,144	6,346	(q)5,535

Year.	Copperas.	Cryolite.	Fluorspar.	Graphite.	Gypsum.	Iodine.	Iron.	
							Ore.	Pig.
1903	3,936	349	13,028	1,810	51,874	29	3,343,510	418,072
1904	3,514	310	13,540	1,815	55,043	30	3,440,846	225,997
1905	4,495	286	15,019	1,971	52,886	27	3,698,563	380,324
1906	4,712	(k)	15,493	2,013	63,516	46	3,851,791	479,772
1907	6,212	(k)	16,624	2,176	70,737	44	3,904,400	275,170
1908	4,393	(k)	14,925	2,469	60,992	51	3,067,737	257,849
1909	2,232	(k)	14,534	2,377	63,220	59	2,825,007	471,045
1910	2,929	(k)	17,988	3,424	89,590	70	2,952,634	786,854
1911	4,151	(k)	23,073	3,822	102,754	73	2,581,698	829,393
1912	3,386	(k)	21,145	4,501	108,624	79	2,309,628	1,016,261
1913	5,382	(k)	25,523	5,423	132,693	92	2,613,158	782,911
1920	(r)	(k)	14,691	2,610	79,902	(o)	160,520	125,922

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Year.	Lead.					Lime, Chloride of.	Magnesite.	Magnesium Chloride.	Manganese Ore.
	Ore.	Pig and Scrap.	Litharge.	White.	Red.				
1903 ...	1,270	30,243	5,175	20,765	7,617	28,849	2,812	17,008	11,138
1904 ...	1,312	23,169	5,410	16,638	7,544	30,078	1,917	16,706	5,536
1905 ...	1,496	32,515	4,466	16,478	8,902	30,667	2,552	21,673	4,116
1906 ...	1,915	27,067	2,493	14,022	9,450	29,485	2,843	26,708	2,555
1907 ...	1,296	38,259	4,470	13,551	9,371	24,946	3,264	29,566	3,554
1908 ...	1,189	29,967	5,242	13,733	9,602	23,895	4,021	27,525	2,333
1909 ...	2,556	31,674	4,750	10,583	9,658	27,314	3,702	31,334	4,488
1910 ...	2,382	31,025	4,865	13,595	10,444	24,716	5,399	35,352	4,557
1911 ...	3,746	32,063	5,496	14,962	11,321	27,107	4,496	43,896	9,615
1912 ...	3,273	38,122	6,480	12,750	10,116	32,254	7,132	39,559	7,790
1913 ...	4,458	41,369	6,203	12,402	8,898	36,473	5,857	55,505	9,388
1920...	558	8,758	712	(e)20,810	3,370	.....	4,538	.....	(j)

Year.	Mineral Pigments.	Nickel.	Osokerite.	Petroleum Products. (f)		Phosphorus.	Phosphate Rock.
				Illuminating Oil.	Lubricating Oil.		
1903.....	15,161	700	2,027	701	1,975	286	4,342
1904.....	16,395	1,203	2,447	760	1,763	236	3,222
1905.....	17,603	1,034	2,757	7,286	1,746	228	3,720
1906.....	4,290	954	509	673	9,982	228	5,484
1907.....	4,097	930	692	770	10,552	165	1,494
1908.....	15,675	1,349	921	1,008	10,852	160	1,196
1909.....	18,130	1,606	1,300	588	11,621	168	5,429
1910.....	19,355	1,381	1,642	472	17,141	160	5,044
1911.....	22,426	1,592	1,295	274	18,905	192	10,591
1912.....	27,313	1,677	1,167	244	19,635	219	7,032
1913.....	30,348	1,673	1,999	.....	.....	192	6,885
1920.....	780	56	728	1,162	2,573	108	780

Year.	Potassium Salts.						Potassium and Potassium-magnesium Sulphate.	Pumice Stone. (g)	Pyrite.
	Carbonate	Cyanide. (f)	Chloride.	Hydroxide.	Iodide.	Nitrate.			
1903 ...	13,121	2,017	125,302	13,006	154	9,671	56,455	794	32,611
1904 ...	10,777	3,290	140,765	24,963	174	10,405	64,400	943	30,666
1905 ...	11,963	4,005	156,440	22,246	170	12,140	67,286	939	35,195
1906 ...	12,543	5,049	171,994	21,772	168	11,564	54,557	1,578	35,829
1907 ...	13,314	5,210	173,638	20,254	146	12,668	128,344	2,590	24,183
1908 ...	13,009	4,887	174,345	25,048	127	10,643	181,975	6,055	16,384
1909 ...	13,797	6,283	216,286	27,095	122	12,498	201,393	9,140	11,564
1910 ...	13,099	6,329	266,783	29,094	124	14,728	273,614	7,643	9,871
1911 ...	14,584	6,554	329,751	28,921	133	16,430	392,129	22,075	11,015
1912 ...	12,991	6,715	286,614	26,623	143	14,451	134,079	19,978	27,917
1913 ...	16,271	6,678	393,320	44,113	160	16,058	192,565	4,052	28,214
1920...	3,885	1,539	2,253	.....	(o)	4,647	158,368	241	2,664

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Year.	Quicksilver.	Salt.	Slag and Slag Wool.	Sodium Salts.					
				Bicarbonate.	Carbonate.	Hydroxide.	Nitrate. (Chile Saltpeter).	Soda, Calcined.	Sulphate and Sulphite.
1903...	62	399,184	14,674	1,016	2,982	5,886	17,583	46,086	47,660
1904...	43	347,351	38,587	1,524	3,050	5,084	21,075	43,590	45,506
1905...	48	284,203	28,032	1,881	4,113	5,925	20,531	46,768	54,377
1906...	21	97,878	49,912	2,120	5,860	6,101	22,099	41,598	64,217
1907...	26	92,288	46,680	1,764	2,680	7,462	22,715	36,802	69,231
1908...	26	318,395	74,821	1,713	3,842	7,626	23,549	56,839	78,510
1909...	29	364,107	61,674	1,292	2,968	8,314	28,019	54,493	74,512
1910...	31	370,074	58,832	1,370	5,994	9,295	27,095	56,545	89,208
1911...	36	374,633	88,423	1,598	1,782	10,635	27,937	60,102	89,110
1912...	37	430,137	128,740	1,584	1,057	12,460	27,431	66,760	85,416
1913...	53	432,387	.....	1,869	1,354	13,030	27,507	69,993	83,239
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1920...	4	1,253,317	.....	.....	2,702	9,822	4,121	.....	15,487

Year.	Sodium and Potassium Salts.		Stassfurt Salts.	Strontium.		Sulphur.	Sulphuric Acid.
	Chromates.	Sulphides.		Carbonate. (n)	Salts.		
1903	2,977	5,845	501,385	819	1,389	1,052	50,109
1904	2,272	5,489	631,762	613	1,207	1,418	52,696
1905	2,133	6,569	852,454	613	1,386	1,198	48,701
1906	2,877	6,730	831,293	1,726	1,578	1,582	52,720
1907	3,016	8,103	839,889	1,462	1,671	1,501	49,950
1908	4,402	6,536	818,677	1,494	1,822	1,765	60,588
1909	4,789	7,596	946,457	2,636	1,832	1,935	63,817
1910	4,246	8,679	1,181,208	2,456	1,275	2,727	66,581
1911	5,193	7,837	1,154,974	595	.....	1,757	64,888
1912	5,167	7,640	.....	1,830	138	1,746	75,962
1913.....	5,667	9,226	.....	1,958	330	3,472	64,968
.....	.....	.....	.....	.....	.....	.....	.....
1920	571	.....	843,075	16	.....	320	6,939

Year.	Superphosphate.	Tin, Crude.	Zinc.				Zinc White Zinc Gray and Lithophone.
			Ore.	Spelter and Scrap.	Drawn or Rolled.	Sulphate.	
1903.....	99,672	2,581	40,458	67,057	15,715	264	27,527
1904.....	129,925	2,965	40,488	70,063	17,917	332	26,898
1905.....	115,886	3,259	38,972	67,675	18,982	296	27,877
1906.....	104,713	4,845	42,546	69,142	17,794	426	26,296
1907.....	115,049	4,244	34,863	93,649	21,484	425	30,453
1908.....	125,464	3,707	39,450	75,290	18,661	347	26,372
1909.....	168,988	5,431	51,994	82,225	18,961	342	25,970
1910.....	211,812	7,530	59,440	8,803	26,623	334	36,350
1911.....	221,521	7,582	48,998	81,042	36,093	387	34,419
1912.....	271,349	6,368	51,242	105,328	26,379	.....	44,169
1913.....	282,653	6,437	44,731	109,606	24,965	.....	46,106
.....	.....	.....	.....	.....	.....	.....	.....
1920.....	1,040	226	31,097	30,802	6,196	.....	(t)

(a) From *Statistisches Jahrbuch für das Deutsches Reich*. (b) Includes celestite. (c) Includes cryolite after 1905. (d) Includes precipitated chalk. (e) Includes other carbides. (f) Includes sodium cyanide. (g) Includes tripoli. (h) Includes nickel ore. (i) Included under chromium ore. (j) Included with iron ore. (k) Included under bauxite. (l) Included under magnesium chloride. (m) Includes all alkali metals. (n) Includes witherite. (o) Included with bromine salts. (p) Includes bromine, iodine, and potassium iodide. (q) Includes iron and zinc sulphates. (r) Included with copper sulphate. (s) Includes zinc white and lithopone. (t) Included with white lead.

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GREECE

The statistics of mineral production in Greece, according to the latest available reports, are summarized in the following table:

MINERAL PRODUCTION OF GREECE (*a*)
(In metric tons or dollars; 1 drachma = 20 cents)

Year.	Chrome Ore.	Emery.	Gypsum.	Iron Ore.	Iron Ore, Manganiferous.	Lead, Soft.	Lead Ore, Argentiferous.	Lead, Argentiferous.	Lead, Fume.	Lignite.
1907..	11,730	10,652	105	768,863	92,970	(*b*)	(*b*)	13,814	(*b*)	11,719
1908..	4,350	7,471	61	531,368	65,757	(*b*)	(*b*)	15,892	(*b*)	8,786
1909..	9,600	8,193	208	475,616	54,926	(*b*)	(*c*)	14,948	(*b*)	3,873
1910..	9,450	12,939	243	535,482	50,015	(*c*)	8,355	16,710	(*b*)	1,500
1911..	12,915	10,544	1,263	496,731	27,482	.....	182,324	14,283	.....	.....
1912..	6,468	3,359	127	376,931	12,212	.....	175,463	14,489	.....	.....
1913..	6,342	5,560	2,230	310,078	6,323	.....	159,348	18,309	.....	170
1914..	7,059	16,112	639	299,286	1,315	.....	151,581	20,684	.....	20,002
1915..	10,420	14,338	1,648	157,340	1,041	.....	104,905	11,595	.....	39,745
1916..	9,880	19,871	356	84,985	818	.....	95,418	9,424	.....	116,946
1917..	6,750	16,440	44	63,364	509	.....	36,558	1,422	.....	157,956
1918..	10,887	11,100	.....	67,874	970	.....	.....	4,092	.....	208,300
1919..	9,054	9,300	521	46,939	418	.....	3,334	3,841	.....	182,951
1920..	13,388	11,089	1,147	44,751	4	.....	23,582	5,016	.....	182,880

Year.	Magnesite.			Manganese Ore.	Pussolan.	Sea Salt.	Sulphur.	Zinc Ore.	
	Crude.	Bricks.	Calcined.					Blende.	Calamine, Calcined.
1907...	55,816	(*b*)	(*b*)	11,139	39,637	26,966	(*b*)	(*b*)	30,346
1908...	63,079	(*b*)	(*b*)	10,750	52,312	23,988	(*b*)	28,739	24,101
1909...	56,797	294	16,609	5,374	46,238	29,448	(*b*)	41,656	30,159
1910...	18,073	295	19,982	41	31,609	25,978	(*b*)	(*f*)5,845	28,898
1911...	86,956	275	27,530	(*e*) 733	31,647	26,952	(*h*)31,905	35,856	30,512
1912...	106,338	496	33,848	(*e*)8,082	19,400	31,400	(*h*)31,938	39,585	28,912
1913...	98,517	.....	31,815	(*e*) 556	24,906	19,215	(*h*)128,932	30,717	20,646
1914...	136,701	493	28,563	558	28,909	29,717	(*h*)129,129	32,440	22,308
1915...	159,981	161	27,248	408	13,471	16,856	(*h*) 12,121	33,121	20,209
1916...	199,484	*Nil.*	29,933	3,600	8,564	34,522	(*h*) 41,495	25,853	12,612
1917...	162,938	*Nil.*	14,107	*Nil.*	*Nil.*	45,560	9,535	14,290	7,258
1918...	31,262	.....	.....	5,126	.....	.....	.....	.....	1,500
1919...	62,408	.....	9,110	.....	.....	28,831	2,238	3,334	2,250
1920...	79,323	.....	2,394	.....	.....	57,285	.....	2,591	1,154

(*a*) Statistics up to 1903 communicated by E. Grohmann, Seriphos. Statistics for 1903 and subsequent years from *Statistique du Mouvement Minier de Grèce*. The figures represent sales or shipments. (*b*) Not reported. (*c*) No sales, but production of lead ore is reported at 240,013 tons in 1909 and 185,207 tons in 1910. (*e*) Sales. (*f*) Production in 1910 was 37,108 tons. (*h*) Including pyrite.

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INDIA

The official statistics of mineral production in British India are summarized in the subjoined table:

MINERAL PRODUCTION OF INDIA (a)
(In metric tons or dollars)

Year.	Amber. (g)	Bauxite.	Coal.	Chromite.	Copper Ore.	Corundum.	Diamonds, Carats.	Gold. (c)	Graphite.	Gypsum.	Iron Ore.	Jade. (a) Cwt.	Lead Ore.	Magnesite.
1907	$1,925	.....	11,325,696	18,596	.....	.....	628.0	$10,348,795	2,472	.....	69,829	2,636	.....	189
1908	1,820	.....	12,974,558	4,821	.....	.....	140.8	10,597,404	2,919	.....	73,457	3,211	.....	7,655
1909	1,435	32	12,060,550	9,398	7	41	147.3	10,728,900	3,182	17,579	84,774	2,487	12,534	749
1910	1,415	67	12,249,744	1,765	1,174	249	77.7	10,717,300	4,319	13,751	55,461	1,908	30,999	5,265
1911	665	12	12,919,587	3,865	2,273	312	53.0	10,890,804	4,047	11,109	372,049	2,063	35,738	3,546
1912	895	962	14,942,340	2,936	9,774	392	27.8	11,054,608	*Nil.*	21,372	589,508	806	25,924	15,626
1913	145	1,202	16,467,337	5,767	3,871	405	115.7	11,152,408	*Nil.*	25,363	376,779	3,281	20,626	16,457
1914	1,370	522	16,729,338	5,982	5,410	63	54.7	11,378,435	*Nil.*	22,626	448,741	3,765	34,227	1,707
1915	995	890	17,379,305	3,828	9,028	120	36.0	11,531,671	71	22,926	396,554	3,693	42,964	7,570
1916	.....	762	17,532,103	20,484	2,714	1,898	3.6	11,206,510	1,341	16,286	418,387	3,783	14,197	17,924
1917	3,420	1,385	18,506,143	27,497	20,432	2,104	18.2	10,811,712	105	16,953	419,927	3,961	72,787	18,495
1918	435	1,212	21,055,160	58,670	3,677	2,046	73.3	10,024,670	82	17,016	500,413	3,203	63,527	5,947
1919	3,080	1,709	22,992,348	37,026	33,277	718	311.9	10,977,886	129	28,774	573,826	2,019	70,280	17,402
1920	8,330	3,995	18,251,406	27,232	28,620	213	85.1	10,315,727	102	34,091	566,989	3,429	96,306	14,577

Year.	Manganese Ore.	Mica.	Monazite.	Petroleum, Gallons.	Rubies, Carats.	Salt.	Saltpeter (Potassium Nitrate.)	Sapphires, Carats.	Silver, Oz.	Talc.	Tin and Tin Ore.	Tungsten Ore.
1907	916,770	2,652	.....	152,045,677	604,217	1,120,427	18,664	(f)	.....	.....	80	.....
1908	685,135	2,720	.....	176,646,320	356,044	1,300,416	19,620	(f)	.....	.....	96	.....
1909	654,974	1,671	.....	233,678,087	265,010	1,274,682	20,953	(f)	27,500	593	85	7
1910	813,721	1,153	.....	214,928,647	262,019	1,577,823	16,140	(f)	49,680	250	167	402
1911	681,015	1,722	.....	225,792,094	288,213	1,347,116	14,679	(f)	103,580	934	189	1,329
1912	643,209	2,227	.....	249,083,518	323,245	1,477,971	14,797	(f)	93,476	800	382	1,697
1913	828,088	2,324	1,253	277,555,225	203,925	1,496,760	14,461	21,353	125,209	2,564	359	1,713
1914	693,824	2,057	1,205	259,342,710	193,333	1,529,002	15,738	56,709	236,446	1,015	374	2,363
1915	457,668	1,379	1,126	287,093,576	167,904	1,956,311	18,389	39,718	285,387	1,094	568	2,687
1916	655,592	2,205	1,313	297,180,787	136,783	1,512,616	25,459	34,100	759,012	1,236	589	4,057
1917	600,325	2,078	1,972	282,759,523	132,409	1,634,519	21,627	32,369	1,581,838	7,955	820	4,615
1918	526,231	2,778	2,151	286,585,011	101,637	2,075,164	25,139	34,949	1,971,783	4,611	896	4,502
1919	546,657	2,326	2,056	305,749,138	88,847	1,921,585	17,833	47,286	2,165,607	2,169	1,505	3,635
1920	748,296	2,385	1,667	293,116,834	88,491	1,656,368	15,260	33,015	2,906,397	3,740	2,320	2,384

(a) Records of the Geological Survey of India. (b) Not reported. (c) £1 = $4.866. (d) Production of iron ore in Bengal only. (e) Exports in cwt. of 112 lb. (f) Included in rubies. (g) £1 = $5.

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ITALY

The following tables itemize the statistics of the production and the foreign commerce of mineral and metallurgical products in Italy:

MINERAL PRODUCTION AND REFINED PRODUCTS OF ITALY (a)
(In metric tons or dollars; 5 lire = $1)

Year.	Alum.	Aluminium Sulphate.	Alunite.	Antimony.	Antimony Ore.	Asphalt, Mastic, and Bitumen.	Asphaltic Rock.	Barytes.
1907.....	3,175	3,010	7,600	610	7,892	38,568	161,126	15,732
1908.....	2,875	2,100	6,165	345	2,521	34,761	134,163	15,432
1909.....	2,580	2,750	5,636	59	1,077	39,165	111,067	16,240
1910.....	2,510	2,773	6,081	*Nil.*	2,194	41,705	162,212	14,420
1911.....	2,725	2,493	6,100	*Nil.*	2,441	50,179	188,133	13,620
1912.....	1,299	2,727	6,002	*Nil.*	1,878	52,707	181,397	13,420
1913.....	1,009	3,308	5,976	76	1,822	56,750	171,097	12,970
1914.....	1,307	3,229	3,700	138	555	33,752	119,853	12,970
1915.....	1,329	2,094	4,850	548	4,334	25,701	47,650	17,850
1916.....	(b)	(b)	3,370	660	6,509	16,662	16,829	21,650
1917.....	(b)	(b)	4,855	535	5,789	13,608	8,645	19,000
1918.....	(b)	(b)	2,217	367	3,369	8,310	22,309	14,945
1919.....	(b)	(b)	3,507	10	25	14,872	78,000	19,390
1920.....	(b)	(b)	3,445	80	882	29,015	106,642	15,380
1921(l)...	(b)	(b)	1,170	40	.....	.....	91,800	13,500

Year.	Borax, Refined.	Boric Acid.		Coal. (c)	Coal (Briquettes).	Coke.	Copper.		
		Crude.	Refined.				Ore.	Ingot, etc.	Sulphate.
1907...	880	2,305	466	453,137	787,087	717,704	167,619	17,491	45,263
1908...	1,024	2,520	429	480,029	822,699	813,842	106,629	18,280	42,598
1909...	1,110	2,431	578	555,073	924,479	999,381	90,272	20,005	28,551
1910...	912	2,502	695	562,154	918,055	1,160,543	68,369	22,467	36,236
1911...	738	2,648	444	555,137	794,206	863,493	68,136	22,908	44,626
1912...	813	2,309	760	663,812	876,565	437,706	86,001	26,659	52,311
1913...	1,070	2,410	743	701,079	896,091	1,336,382	89,487	24,625	44,497
1914...	1,164	2,537	838	781,288	968,600	1,276,318	88,953	1,839	31,302
1915...	829	2,497	1,277	953,082	721,409	1,365,109	74,470	1,840	41,272
1916...	(b)	2,293	1,114	1,305,840	(b)	(j)515,561	88,475	1,867	(b)
1917...	(b)	2,335	(b)	1,722,157	(b)	(j)447,387	86,842	1,248	(b)
1918...	(b)	2,210	(b)	2,171,397	(b)	(j)262,515	82,302	1,114	(b)
1919...	(b)	2,053	(b)	1,157,541	(b)	(j)302,737	16,653	1,243	(b)
1920...	(b)	1,719	(b)	1,739,922	(b)	(j) 95,727	16,209	635	(b)
1921(l).	(b)	2,490	(b)	1,134,250	(b)	(j) 50,000	22,700	100	(b)

Year.	Gold.		Graphite.	Iron and Steel.				
	Ore.	Bullion.		Ore.	Pig.	Bar, Sheet, Pipe, Wire, etc.	Tin Plate.	Steel.
1907.....	13,475	$41,000	10,989	517,952	148,996	248,157	24,423	346,749
1908.....	14,671	48,223	12,914	539,120	158,100	302,509	28,277	437,674
1909.....	2,890	18,230	11,583	505,095	254,904	281,098	35,880	608,795
1910.....	2,147	11,746	12,510	551,259	399,700	311,210	42,670	670,983
1911.....	2,080	16,440	12,621	373,786	302,931	303,223	25,662	697,958
1912.....	2,366	13,271	13,170	582,066	379,989	179,516	28,916	801,907
1913.....	2,047	23,580	11,145	603,116	426,755	591,763	29,185	846,085
1914.....	205	(b)	8,567	706,246	385,340	705,273	26,284	796,152
1915.....	296	1,420	6,176	679,970	377,510	(b)	29,094	1,009,240
1916.....	*Nil.*	(b)	8,182	942,244	467,005	(b)	(b)	1,269,486
1917.....	*Nil.*	(b)	12,117	993,825	471,188	(b)	(b)	1,331,641
1918.....	(b)	(b)	11,653	693,872	313,576	(b)	(b)	992,523
1919.....	(b)	(b)	7,626	613,025	239,710	(b)	(b)	731,823
1920.....	(b)	(b)	5,398	389,876	88,072	(b)	(b)	773,761
1921(l)...	80	664	5,750	274,000	50,400	(b)	(b)	683,200

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Year.	Lead.		Magnesite.	Manganese Ore.	Manganiferous Iron Ore.	Marble.	Petroleum. Crude.	Refined Petroleum and Benzene.
	Ore.	Pig.						
1907.....	(d)43,037	22,978	.....	3,654	18,874	434,512	8,326	10,556
1908.....	36,649	26,003	.....	2,750	17,812	425,690	7,088	10,876
1909.....	37,945	22,133	.....	4,700	25,830	391,295	5,895	11,077
1910.....	36,840	14,495	.....	4,200	25,700	427,274	7,069	12,149
1911.....	39,008	16,684	.....	3,515	6,482	497,741	10,390	15,569
1912.....	41,680	21,450	.....	2,641	*Nil.*	522,088	7,479	13,792
1913.....	44,654	21,674	600	1,622	*Nil.*	509,342	6,572	11,160
1914.....	45,538	20,464	1,140	1,649	*Nil.*	431,087	5,542	11,873
1915.....	41,590	21,812	9,200	12,577	*Nil.*	246,883	6,105	14,332
1916.....	39,460	24,362	18,252	18,147	4,360	200,700	7,035	20,467
1917.....	39,076	16,237	31,070	24,532	4,806	134,233	5,668	4,370
1918.....	37,583	18,332	28,882	31,896	805	87,483	4,907	3,668
1919.....	32,130	16,530	35,930	30,841	68	265,774	4,851	3,544
1920.....	40,064	15,947	33,850	36,158	90	352,421	4,937	2,978
1921(l).....	26,500	11,500	9,400	4,700	5,980	254,000	4,780	.....

Year.	Pumice Stone.	Pyrite (Cupriferous in Part).	Quicksilver.		Salt.			Silver, Bullion. *Kg.*
			Ore.	Metal.	Brine.	Rock.	Sea.	
1907.....	11,500	126,925	76,561	434	19,238	31,540	454,454	20,502
1908.....	15,000	131,721	82,534	684	15,180	24,033	473,857	20,746
1909.....	10,000	149,084	97,592	771	15,081	28,026	421,362	20,534
1910.....	12,900	165,688	87,129	894	16,600	39,197	447,440	14,237
1911.....	16,430	165,273	97,803	955	17,251	43,783	460,439	12,143
1912.....	17,386	277,585	88,200	1,000	18,775	39,954	466,220	14,363
1913.....	14,798	317,334	109,379	1,004	17,727	41,323	750,518	13,094
1914.....	14,376	335,531	119,223	1,073	18,396	41,715	762,040	15,254
1915.....	10,242	369,320	110,642	985	17,914	33,267	627,050	15,362
1916.....	9,287	410,290	132,524	1,093	16,943	50,294	330,013	15,131
1917.....	11,312	500,782	(b)	1,071	12,733	43,042	322,666	10,679
1918.....	4,473	482,060	(b)	1,038	13,979	41,947	417,524	10,115
1919.....	13,210	372,574	(b)	548	21,376	49,313	473,059	8,240
1920.....	25,200	321,589	(b)	1,401	22,026	53,639	653,103	9,252
1921(l).....	10,900	448,600	(b)	1,070	45,300	45,400	.....	6,200

Year.	Sulphur.			Talc, Ground.	Zinc.	
	Crude (Fused).	Ground.	Refined.		Ore.	Spelter.
1907.....	426,972	151,338	160,617	8,850	160,517	188
1908.....	445,312	160,693	156,995	9,410	(e)152,254	(b)
1909.....	435,060	132,531	144,579	9,530	(g)130,890	(b)
1910.....	430,366	171,570	169,093	11,580	(g)146,307	(b)
1911.....	414,161	158,977	166,802	14,156	139,719	(b)
1912.....	389,451	164,864	168,514	14,324	149,776	(b)
1913.....	386,310	(k)20,096	151,713	21,350	158,278	(b)
1914.....	377,843	(k)25,715	149,100	22,478	145,914	(b)
1915.....	358,107	(k)22,133	116,358	21,942	80,622	(b)
1916.....	269,374	(k)18,591	(b)	25,933	94,043	258
1917.....	211,847	(k)18,227	(b)	20,811	79,453	367
1918.....	234,296	19,094	(b)	17,369	67,116	1,188
1919.....	226,126	29,190	(b)	17,184	65,629	1,282
1920.....	263,603	32,496	(b)	20,570	95,985	1,177
1921(l).....	284,600	28,800	(b)	21,000	69,000	380

(a) From *Rivista del Servisio Minerario.* (b) Not reported. (c) Includes anthracite, lignite, fossil wood, and bituminous schist. (d) Does not include 680 tons lead and zinc ore. (e) Includes 560 tons lead-zinc ore. (g) Includes 290 and 300 tons lead-zinc ore, 1909 and 1910. (j) Metallurgical coke only. (k) Crude, ground. (l) Preliminary figures, Ministero di Agricoltura, Ispettorato Centrale delle Miniere.

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MINERAL IMPORTS OF ITALY (a)

(In metric tons or dollars; 5 lire = $1)

Year.	Antimony.	Arsenic. Kg.	Asbestos.	Asphaltum.	Barytes.	Borax and Boric Acid.	Cement and Hydraulic Lime.	Lime.
1906.....	50	5,300	2,171	2,854	1,400	163	18,937	7,714
1907.....	163	3,100	3,110	3,661	1,540	307	29,024	6,156
1908.....	153	2,800	2,548	3,730	1,523	333	28,935	7,210
1909.....	293	4,800	2,285	3,826	2,094	386	25,250	11,120
1910.....	342	5,300	2,051	3,365	1,777	363	22,183	9,007
1911.....	353	5,500	3,892	4,238	2,024	741	24,467	7,942
1912.....	636	4,600	4,080	3,548	1,986	380	23,423	6,809
1913.....	513	2,500	4,750	4,300	1,771	159	19,950	5,501
1914.....	198	3,500	2,710	2,924	1,409	280	15,002	3,810
1915.....	825	1,700	5,380	4,139	1,319	719	5,969	2,052
1916.....	155	2,700	5,428	1,090	1,398	985	6,606	2,943
1917.....	1,247	*Nil*	3,729	1,381	1,121	632	64,809	1,408
1918.....	1,164	*Nil*	3,165	2,111	1,064	350	5,365	634
1919.....	555	3,100	3,650	4,663	795	564	11,572	95
1920.....	293	11,100	3,968	1,750	1,545	1,316	15,789	7
1921.....	82	18,000	1,486	1,410	.....	227	44,542	642

Year.	Coal. (a)	Copper, Ore.	Copper, Cement.	Copper, Brass and Bronze.	Copper and Iron Sulphates.	Gold. Kg.	Graphite.
1906.....	7,673,435	9,363	802	21,458	25,060	4,571	361
1907.....	8,300,439	18,023	888	28,937	15,939	4,443	267
1908.....	8,452,320	14,784	344	28,025	25,037	(d) 8,367	383
1909.....	9,303,506	11,303	630	22,391	9,137	(d) 8,311	141
1910.....	9,338,752	7,550	456	30,339	13,599	(d) 13,188	229
1911.....	9,595,882	6,607	277	38,650	37,929	(d) 12,712	246
1912.....	10,057,228	6,253	578	43,729	36,602	(d) 10,545	403
1913.....	10,834,008	737	352	39,552	30,472	(d) 9,940	567
1914.....	9,758,877	850	*Nil*	28,422	21,939	(d) 10,281	162
1915.....	8,369,029	571	*Nil*	54,718	14,081	(d) 6,389	1,506
1916.....	8,065,041	2,453	*Nil*	68,365	6,126	(d) 343	1,071
1917.....	5,037,497	467	*Nil*	93,115	231	96	1,219
1918.....	5,840,922	404	502	79,594	23	149	1,011
1919.....	6,226,451	31	*Nil*	79,429	2,466	1,324	895
1920.....	5,619,978	*Nil*	*Nil*	22,584	857	1,771	1,617
1921.....	7,470,484	25	*Nil*	20,989	812	389	511

Year.	Iron.		Iron and Steel Scrap.	Lead.		Lead Oxide and Carbonate.	Mineral Paints.
	Ore.	Pig.		Ore. (c)	Metal and Alloys in Pigs.		
1906.....	6,452	168,985	344,977	4,526	10,958	984	964
1907.....	22,046	231,042	362,567	4,342	9,231	953	1,119
1908.....	31,090	254,239	326,119	5,620	11,742	1,474	2,616
1909.....	28,150	246,730	416,354	3,003	10,011	1,132	1,713
1910.....	17,673	204,854	386,604	1,426	14,674	1,225	1,775
1911.....	50,554	234,770	392,703	6,042	20,187	1,077	1,756
1912.....	18,606	267,355	343,728	12,391	15,627	917	1,962
1913.....	8,026	221,688	326,231	9,552	11,494	682	2,410
1914.....	4,592	219,995	254,892	5,736	9,820	533	2,053
1915.....	7,607	240,535	261,468	6,181	17,326	183	1,811
1916.....	1,237	302,333	342,706	12,551	14,358	224	1,130
1917.....	313	315,953	227,234	4,838	26,283	38	481
1918.....	4,952	115,211	17,667	5,478	40,310	29	362
1919.....	12,553	216,138	96,247	4,672	17,917	75	510
1920.....	1,607	157,193	142,857	3,684	1,510	398	1,307
1921.....	1,054	65,989	66,619	2,706	434	47	1,218

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Year.	Nickel Alloys and Manufactures.	Petroleum.	Phosphate Rock.	Potash, Ammonia, and Caustic Soda.	Potassium Sulphate.	Quicksilver.	Silver. *Kg.*	Slag, Metalliferous.
1906.....	717	64,541	307,762	16,718	1,534	12	20,410	88,118
1907.....	725	72,715	384,896	15,225	3,866	11	21,829	5,378
1908.....	1,079	82,373	531,921	14,962	4,891	10	(d)83,434	1,122
1909.....	540	88,929	478,199	15,547	5,333	2.2	(d)47,234	878
1910.....	1,311	84,748	422,714	16,983	7,753	2.5	(d)55,516	3,153
1911.....	1,584	119,245	479,042	16,312	9,493	2.0	(d)52,576	95
1912.....	1,742	113,231	466,144	17,816	13,466	1.5	(d)79,763	164
1913.....	1,200	115,374	529,776	17,407	9,454	0.3	(d)87,856	2,560
1914.....	1,112	116,276	513,998	16,382	3,708	*Nil*	102,090(d)	700
1915.....	1,812	111,426	456,901	21,977	900	4.3	(d)83,018	1,780
1916.....	1,991	97,747	431,425	19,878	*Nil*	42.0	(d)50,859	1,116
1917.....	3,293	94,183	230,159	17,860	*Nil*	*Nil*	(d)65,966	133
1918.....	3,215	72,238	232,129	15,219	*Nil*	*Nil*	(d)10,924	22
1919.....	2,136	94,333	449,317	11,887	*Nil*	*Nil*	(d)18,578	118
1920.....	212	121,535	400,001	28,073	1,005	*Nil.*	(d) 5,216	330
1921.....	81	213,308	567,543	15,702	1,606	0.1	(d) 2,051	5,188

Year.	Sodium Salts.		Sod. and Pot. Nitrates, Refined.	Tin.		Zinc.			
	Carbonate.	Nitrate (Crude).		Block.	Mnfrs.	Ore.	Oxide.	Spelter and Old.	Mnfrs.
1906....	31,170	32,508	395	3,361	167	2,042	1,920	6,835	4,421
1907....	35,538	41,457	668	2,771	183	11	1,962	8,152	5,407
1908....	38,268	60,784	428	2,602	187	7	2,026	9,339	5,112
1909....	38,252	43,658	532	2,555	191	13	1,571	9,222	4,572
1910....	45,174	61,192	1,083	2,760	238	18	2,001	8,971	5,416
1911....	45,596	59,561	417	2,524	211	428	2,100	10,742	5,892
1912....	49,284	54,634	529	2,627	157	*Nil*	2,550	11,955	5,833
1913....	52,332	67,418	574	2,973	144	5	2,983	12,448	6,071
1914....	48,115	59,850	310	2,744	110	*Nil*	2,348	10,518	4,002
1915....	53,191	71,730	2	4,245	38	*Nil*	1,833	12,843	1,087
1916....	45,212	85,649	103	2,916	32	*Nil*	1,376	17,766	1,017
1917....	29,583	104,150	115	3,254	8	*Nil*	806	18,421	974
1918....	22,651	97,012	846	2,335	6	*Nil*	415	10,204	641
1919....	27,235	12,868	71	2,841	44	*Nil*	1,515	16,012	3,282
1920....	34,252	49,204	534	2,063	169	*Nil.*	2,637	3,769	3,445
1921....	6,749	20,881	310	2,145	117	*Nil.*	822	663	2,995

MINERAL EXPORTS OF ITALY (a)

(In metric tons or dollars; 5 lire = $1)

Year.	Antimony.	Asbestos.	Asphaltum.	Barytes.	Borax and Boric Acid.	Cement and Hydraulic Lime.	Lime.	Coal. (e)
1906.....	208	205	27,176	147	2,777	6,774	3,118	31,666
1907.....	115	142	26,036	152	1,330	4,477	3,224	40,769
1908.....	10	193	24,158	724	1,005	5,439	2,533	46,774
1909.....	8	527	21,978	125	1,704	7,534	3,525	51,343
1910.....	2	485	26,125	150	1,536	7,131	5,764	48,144
1911.....	*Nil*	517	28,455	353	1,347	10,742	9,440	40,800
1912.....	11	571	13,158	381	1,661	55,091	6,736	26,298
1913.....	*Nil*	672	6,645	234	1,373	55,906	5,161	192,002
1914.....	51	509	6,367	210	1,195	40,880	5,161	84,908
1915.....	3	148	6,720	3,288	1,702	40,430	627	79,090
1916.....	188	259	4,103	2,755	2,098	42,425	114	94,319
1917.....	40	166	111	1,113	1,113	8,474	180	77,432
1918.....	*Nil*	118	1	523	1,335	1,319	617	59,157
1919.....	111	141	430	1,977	1,786	11,370	619	83,657
1920.....	843	294	2,357	4,298	1,279	12,515	300	77,061
1921.....	191	308	6,077	.....	1,314	7,050	3,061	205,100

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Year.	Copper, Ore.	Copper and Iron Sulphate.	Gold. *Kg.*	Graphite.	Iron.		
					Ore.	Pig.	Scrap.
1906.....	189	102	1,476	4,904	1,833	254	.....
1907.....	179	835	802	7,474	26,000	121	.....
1908.....	188	721	7,588	7,009	35,653	176	1,676
1909.....	233	1,211	15,452	8,125	46	209	1,480
1910.....	969	741	16,643	7,647	9,892	327	2,450
1911.....	130	157	14,144	7,633	22,851	290	3,390
1912.....	267	1,445	13,993	7,785	12,318	51	5,662
1913.....	285	609	16,440	8,329	9,660	555	6,895
1914.....	78	1,856	6,724	7,589	8,944	69	4,636
1915.....	2	62	1,072	6,508	157	40	2,576
1916.....	*Nil*	170	632	5,615	30	2	13
1917.....	20	403	108	7,992	327	5	162
1918.....	*Nil*	338	3	7,310	66	20	*Nil*
1919.....	*Nil*	1,274	104	2,185	1,679	53	*Nil*
1920.....	1,978	5,875	47	3,769	381	42	1,604
1921.....	1,024	2,997	146	1,675	1,531	266	102

Year.	Lead.			Mineral Paints.	Phosphate Rock.	Quicksilver.	Salt.	Silver. *Kg.*
	Ore.	Lead Alloys, in Pigs.	Oxide and Carbonate.					
1906.....	8,356	2,005	315	4,502	1,652	278	126,199	18,262
1907.....	3,213	1,548	240	4,602	4,560	350	99,191	18,164
1908.....	2,041	1,243	219	3,446	2,271	565	85,489	(*d*)28,716
1909.....	1,037	782	211	4,310	2,979	714	103,895	(*d*)37,653
1910.....	4,122	933	197	3,945	3,627	781	122,404	(*d*)22,403
1911.....	15,791	637	196	4,182	5,427	1,037	119,173	(*d*)28,434
1912.....	17,062	4,122	75	4,417	1,285	993	155,543	(*d*)28,275
1913.....	16,950	577	314	4,166	4,171	993	161,118	(*d*)18,786
1914.....	15,403	189	687	4,220	8,569	760	124,860	(*d*)12,233
1915.....	3,817	14	339	3,458	1,809	853	108,991	(*d*)28,016
1916.....	9,871	4	1,582	2,766	*Nil*	767	31,135	(*d*) 4,898
1917.....	7,622	3	512	1,360	*Nil*	1,115	1,013	(*d*) 1,364
1918.....	5,845	2	16	866	5	1,219	10,818	(*d*) 737
1919.....	5,600	502	225	770	*Nil*	492	37,197	(*d*) 7,333
1920.....	9,858	3,564	1,678	2,043	5	1,029	126,671	(*d*)20,021
1921.....	11,281	23,013	923	2,358	1	938	80,936	(*d*) 2,051

Year.	Slag.	Sodium Salts.			Sulphur.	Tin.		Zinc.		
		Carbonate	Nitrate (Crude).	Sod. and Pot. Nitrates, Refined.		Block.	Manufactures	Ore.	Oxide.	Spelter and Scrap.
1906....	8,990	253	80	133	336,339	303	81	144,244	687	639
1907....	10,934	200	138	102	297,378	434	117	142,271	727	1,182
1908....	12,122	583	37	57	330,093	180	173	122,456	395	984
1909....	17,163	517	464	163	329,233	85	126	123,936	212	983
1910....	10,488	321	98	45	344,513	164	245	127,315	957	845
1911....	8,274	180	168	15	398,592	166	319	133,471	1,577	616
1912....	19,563	243	27	7	376,387	83	359	152,840	2,165	1,222
1913....	8,251	337	50	10	351,339	152	394	144,644	1,313	1,566
1914..	7,822	123	179	12	260,333	179	313	89,776	1,219	1,234
1915....	715	94	*Nil*	5	393,908	36	364	59,734	2,560	86
1916....	495	31	*Nil*	108	326,435	100	388	80,180	1,294	126
1917....	30	30	*Nil*	*Nil*	118,340	1	130	50,355	508	13
1918....	300	25	*Nil*	*Nil*	192,227	2	25	50,551	115	5
1919....	160	26	3	*Nil*	120,458	46	47	57,877	114	5
1920....	192	67	51	8	148,046	159	123	93,543	1,652	79
1921....	3,705	65	548	2	71,833	184	89	58,827	713	527

(*a*) From *Statistica del Commercio speciale di Importazione e di Esportazione.* (*b*) Not reported. (*c*) Includes argentiferous lead ore. (*d*) Includes coin, bullion, sheets, leaf, and partly manufactured. (*e*) Includes coke.

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JAPAN

The total mineral production of the Japanese Empire, according to the latest available returns, is shown in the following table, in metric tons, unless otherwise specified. Figures in full-faced type are either provisional figures or estimates.

MINERAL PRODUCTION OF JAPAN (a)

Year.	Antimony.		Arsenic.	Coal.	Copper.	Gold.	Graphite	Pig. Iron.	Lead.
	Ore.	Metal.	*Kg.*			*Kg.*			
1905....	96	190	8,333	11,955,946	35,944	3,048	209	53,210	2,272
1906....	97	627	5,250	13,468,529	36,963	2,873	177	57,373	4,305
1907....	(b)	248	7,491	13,764,731	40,183	2,938	103	44,447	3,079
1908....	(b)	198	19,838	14,767,638	41,399	3,598	177	42,007	2,910
1909....	10	157	8,061	14,810,412	45,117	3,932	121	54,124	3,337
1910(d)	8	120	11,463	15,433,621	48,545	4,368	145	67,134	3,845
1911(d)	1	97	5,760	17,632,710	53,401	4,690	114	63,793	4,125
1912....	16	80	.....	19,515,285	62,939	5,233	149	69,278	3,764
1913....	.....	(d)21	.....	21,664,784	66,537	4,666	(d)665	71,273	3,779
1914....	.....	3,865	.....	22,296,738	70,481	7,068	574	89,890	4,563
1915....	27	8,347	14,885	20,490,702	75,415	8,293	666	82,979	4,764
1916....	26	**10,393**	.....	20,130,740	100,626	7,893	1,144	101,184	11,343
1917....	11	**5,779**	.....	**26,510,137**	108,037	**7,031**	1,329	139,005	15,807
1918....	54	391	213,000	28,132,772	90,342	7,695	1,808	180,930	10,684
1919....	2	968	835,000	31,461,386	78,443	7,270	1,950	209,005	5,771
1920....	.....	.....	932,000	29,345,348	67,792	7,680	1,133	168,729	4,167

Year.	Manganese Ore.	Petroleum. *Gallons.*	Phosphates.	Pyrite.	Quicksilver. *Kg.*	Salt. *Hectoliters.*	Silver. *Kg.*	Sulphur.	Tin.
1905....	14,017	51,573,754	1,519	25,589	349	(b)	82,886	24,652	26.0
1906....	54,339	47,132,800	3,037	36,038	336	(b)	76,247	27,589	77.0
1907....	20,586	60,005,957	1,721	56,166	456	(f)636,168	95,600	33,329	31.8
1908....	11,130	60,110,558	740	33,867	804	(f)659,202	123,180	33,149	25.7
1909(d) .	8,708	65,165,880	3,781	27,066	335	(f)696,049	127,917	36,900	22.8
1910(d) .	11,120	65,789,858	1,042	78,418	407	(f)696,474	141,613	43,847	23.0
1911....	9,787	63,843,601	2,271	73,879	1,021	(g)569,540	138,287	50,275	24.8
1912....	12,060	72,839,260	7,847	74,929	267	(g)620,067	152,385	54,554	35.6
1913....	2,313	67,557,322	19,047	114,589	92	(g)640,006	146,180	59,448	379.0
1914....	17,076	91,605,170	38,810	115,840	37	(g)610,906	150,958	32,951	245.0
1915....	25,870	101,714,088	57,723	67,536	150	(g)597,161	159,261	89,378	341.0
1916....	49,308	112,798,616	114,810	91,102	192	(g)620,495	172,194	127,874	252.7
1917....	51,375	99,604,397	121,628	121,368	2,246	(g)602,412	221,224	131,667	212.1
1918....	29,759	85,060,783	192,271	105,757	2,555	(g)403,205	205,295	65,619	168.3
1919....	22,877	93,571,312	122,868	126,999	630	.....	160,583	50,631	101
1920....	5,471	92,925,074	97,340	108,862	2,684	.....	152,164	39,600	205

(a) From *Résumé Statistique de l'Empire du Japan*, Tokio. (b) Not reported. (d) From reports of the Japanese Department of Agriculture and Commerce. (f) Metric tons including Taiwan, fiscal years. (g) Metric tons; from *Résumé Statistique de l'Empire du Japan*.

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MEXICO

Statistics showing the production of metals and minerals in Mexico since 1910 have been prepared by the Mexican Secretariat of Industry, Commerce, and Labor. The exports of gold and silver are also given, and in the case of all the other items except coal the exports are stated to be equivalent to the production.

PRODUCTION OF METALS IN MEXICO
(In metric tons)

Year.	Antimony.	Arsenic.	Coal.	Copper.	Gold, Production, Kg.	Gold, Exports, Kg.	Graphite.	Lead.
1910	3,730	*Nil.*	1,304,111	48,160	41,420	37,245	2,571	124,292
1911	4,131	*Nil.*	1,400,000	56,072	37,120	37,120	3,050	116,758
1912	1,698	*Nil.*	982,396	57,245	32,431	32,431	3,518	105,160
1913	937	*Nil.*	.....	52,592	25,810	25,810	4,435	68,343
1914	1,047	*Nil.*	.....	26,621	8,635	8,635	4,259	5,703
1915	739	*Nil.*	.....	206	7,358	7,358	4,189	19,971
1916	829	*Nil.*	.....	28,411	11,748	11,548	470	19,971
1917	2,647	1,285	430,820	50,946	23,542	7,752	420	64,125
1918	3,269	2,206	781,860	70,200	25,313	7,512	6,191	98,837
1919	471	2,246	728,374	52,272	23,586	6,224	4,023	71,376
1920	623	2,092	715,789	49,192	22,864	7,255	3,223	82,518
1921	45	785	.....	15,228	21,275	6,356	2,911	60,513

Year.	Manganese.	Molybdenum.	Quicksilver.	Silver, Production, Kg.	Silver, Exports, Kg.	Tin.	Tungsten.	Zinc.
1910	*Nil.*	*Nil.*	250.6	2,416,669	2,299,113	*Nil.*	*Nil.*	1,833
1911	*Nil.*	*Nil.*	165.1	2,518,202	2,472,759	*Nil.*	*Nil.*	1,593
1912	*Nil.*	*Nil.*	165.2	2,526,715	2,464,780	*Nil.*	*Nil.*	1,266
1913	*Nil.*	*Nil.*	165.7	1,725,861	1,506,540	*Nil.*	*Nil.*	960
1914	*Nil*	*Nil.*	162.4	810,647	727,922	*Nil.*	*Nil.*	793
1915	*Nil.*	*Nil.*	94.0	712,599	712,581	*Nil.*	*Nil.*	5,806
1916	*Nil.*	*Nil.*	52.5	925,993	910,053	0.3	12.2	37,449
1917	73	*Nil.*	33.1	1,306,988	1,120,594	9.2	187.6	45,181
1918	2,878	27.4	163.6	1,944,542	1,883,163	13.5	149.5	20,699
1919	2,794	1.8	118.9	2,049,898	1,988,518	1.6	22.0	11,560
1920	1,137	4.2	75.7	2,068,938	1,801,173	*Nil.*	40.0	15,651
1921	.....	3.2	46.0	2,005,143	1,678,878	0.5	14.4	1,257

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NORWAY

The official statistics of mineral production, imports and exports are summarized in the following tables:

MINERAL PRODUCTION OF NORWAY (*a*)

(In metric tons or dollars; 1 Krone = 27 cents)

Year.	Apatite. (*b*)	Chrome Ore.	Copper.		Feldspar.	Gold.	Iron.		
			Ore.	Ingot.			Ore and Conc.	Pig and Cast.	Ferro-alloys.
1908...	1,771	*Nil.*	33,688	1,806	34,437	*Nil.*	119,656	.....	.....
1909...	1,364	*Nil.*	42,612	1,594	36,439	$8,000	40,389	.....	.....
1910...	703	.....	46,308	1,814	39,507	5,000	102,447	.....	.....
1911...	897	.....	34,705	1,650	34,864	.....	220,524	316	.....
1912...	1,168	115	60,018	2,130	39,844	.....	408,092	309	.....
1913...	757	.....	70,349	2,741	40,842	2,200	544,686	346	.....
1914...	750	81	57,951	2,860	27,967	.....	652,273	6,909	.....
1915...	1,901	350	56,097	2,828	8,778	.....	714,917	8,741	.....
1916...	2,236	2,757	28,670	1,614	12,811	.....	417,899	6,233	.....
1917...	1,832	3,975	39,298	1,810	4,435	.....	302,739	6,295	4,147
1918...	4,562	2,783	50,034	2,856	3,488	.....	95,887	9,007	5,547
1919...	1,168	460	21,974	437	*Nil.*	.....	89,765	2,032	1,523
1920...	*Nil.*	*Nil.*	6,809	556	*Nil.*	.....	79,208	2,852	2,919

Year.	Molybde-nite.	Nickel.		Pyrite, Iron and Copper.	Rutile.	Silver.		Zinc Ore. (*c*)
		Ore.	Metal.			Ore and Native Silver.	Metal. *Kg.*	
1908.....	35	5,190	81	269,129	83	2,262	7,470	2,435
1909.....	30	5,770	62	282,606	.....	2,729	7,780	983
1910.....	.....	19,639	69.8	329,642	116	.....	.....	2,219
1911.....	.....	27,743	172	369,055	76	2,892	7,635	2,240
1912.....	21	30,697	390	464,326	100	4,027	8,400	40
1913.....	12	49,990	690	441,291	77	5,411	9,400	897
1914.....	(*d*)83	48,529	794	414,886	30	7,372	12,904	243
1915.....	(*d*)97	77,018	892	513,335	170	8,431	11,900	1,829
1916.....	(*d*)137	79,903	808	295,354	103	7,515	9,000	1,017
1917.....	(*d*)248	69,639	379	328,694	129	7,147	9,100	269
1918.....	(*d*)228	24,150	33	338,849	2,412	8,599	9,700	268
1919.....	(*d*)83	10,050	222	309,011	4,269	8,947	10,600	337
1920.....	*Nil.*	12,482	422	333,011	3,418	8,018	10,000	148

(*a*) *Tabeller vedkommende Norges Bergværksdrift*, and *Statistisk Aarbok for Kongeriket Norge*.
(*b*) Exports, which represent production. (*c*) Includes lead ore. (*d*) Includes wolframite.

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MINERAL IMPORTS OF NORWAY (a)
(In metric tons)

Year.	Borax. *Kg.*	Cement and Hydraulic Lime.	Coke, Coal, and Cinders.	Copper and Brass.		Iron and Steel.	
				Plates and Bars.	Wares.	Pig.	Bars, Hoops, etc. Wrought Iron.
1909.....	79,786	57,768	2,095,611	(f) 869	1,095	23,167	31,215
1910.....	105,453	20,100	2,159,717	(f) 1,118	1,406	28,034	34,623
1911.....	100,493	17,892	2,187,246	(f) 1,229	1,780	26,569	36,172
1912.....	103,923	27,960	2,474,253	(f) 1,567	2,116	29,908	44,756
1913.....	107,633	31,989	2,482,424	(f) 1,769	2,035	30,682	49,442
1914.....	85,185	42,967	2,764,061	(f) 3,441	2,337	32,254	44,951
1915.....	682,298	27,347	3,095,049	(f) 2,750	2,750	39,670	64,863
1916.....	644,723	87,438	2,833,063	(f) 1,374	2,148	34,712	60,239
1917.....	137,904	41,857	1,226,482	(f) 1,589	2,165	23,400	41,285
1918.....	.....	23,091	1,573,821	(f) 739	1,322	16,025	41,166
1919.....	.....	23,555	1,791,445	(f) 1,928	5,997	16,653	34,690
1920.....	.....	14,864	1,827,250	(f) 1,546	4,537	13,443	51,910
1921.....	.....	18,189	1,066,384	(f) 1,876	3,364	5,973	19,857

Year.	Iron and Steel *Continued.*						Lead in Pigs and Sheets.
	Anchors, Cables, and Chains.	Rails.	Nails, Spikes, and Screws.	Steel.	Sheets and Plates.	Other Manufactures.	
1909.....	1,750	9,051	1,049	1,911	46,195	55,198	536
1910.....	2,131	5,512	852	3,203	56,898	60,282	838
1911.....	2,327	15,312	1,129	3,908	65,847	72,170	939
1912.....	2,591	12,276	1,313	4,239	84,525	86,552	1,142
1913.....	2,479	15,291	1,613	3,197	76,158	86,411	1,054
1914.....	2,651	21,834	1,340	2,638	75,145	91,496	1,079
1915.....	2,260	32,345	1,644	1,645	112,694	111,546	1,482
1916.....	3,198	16,710	2,396	2,249	84,622	97,097	1,517
1917.....	1,338	776	2,372	1,394	25,972	68,539	1,059
1918.....	967	2,481	1,769	2,177	25,365	54,390	730
1919.....	2,043	10,021	1,378	1,459	66,579	75,396	1,254
1920.....	2,489	14,585	2,025	1,581	64,808	101,282	680
1921.....	842	23,467	575	512	31,932	54,240	379

Year.	Lead-white and Zinc Oxide.	Petroleum and Paraffin.	Potash.	Salt.	Sodium Nitrate.	Soda.	Sulphur. (b)	Tin in Blocks, etc.	Zinc in Bars, Plates, etc.
1909...	1,304	63,042	475	164,195	572	8,357	10,293	280	1,336
1910...	1,277	63,976	536	182,288	546	9,270	10,279	358	5,891
1911...	1,465	71,496	524	192,354	786	9,566	8,782	353	9,173
1912...	1,864	80,023	541	214,817	418	15,877	13,911	439	9,636
1913...	2,502	79,253	572	214,987	1,337	16,255	15,411	333	13,560
1914...	2,293	87,268	942	204,036	141	20,325	10,347	662	17,492
1915...	2,478	55,945	1,111	263,507	31	23,798	6,804	1,029	31,811
1916...	2,434	103,902	965	316,166	6,426	25,860	7,262	741	28,891
1917...	2,606	51,344	562	279,762	11,403	27,748	963	100	16,053
1918...	419	41,180	54	310,546	19,601	21,315	731	55	393
1919...	1,792	105,311	1,415	177,712	29,578	15,037	600	352	31,483
1920...	2,426	65,529	1,197	141,390	17,074	36,724	843	358	15,743
1921...	2,683	65,194	257	121,392	8,451	6,838	491	212	7,635

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MINERAL EXPORTS OF NORWAY (a)
(In metric tons)

Year.	Apatite.	Copper.			Feldspar.	Iodine. *Kg.*	Iron Ore.
		Ore.	Ingot.	Scrap.			
1908	1,771	156	1,260	385	29,896	11,097	110,425
1909	1,365	3,245	1,335	543	33,092	13,020	88,933
1910	703	241	1,377	583	39,507	13,114	88,715
1911	500	924	1,091	575	34,864	16,982	180,932
1912	.....	423	1,551	366	39,844	11,642	404,990
1913	.....	74	2,644	167	40,843	12,149	568,763
1914	.....	0.1	2,558	502	27,966	3,096	467,796
1915	.....	438	2,691	293	12,607	576	425,892
1916	.....	2,175	1,430	359	12,811	1,131	404,700
1917	.....	809	1,900	.....	4,435	.....	197,735
1918	.....	725	1,254	4	3,489	5,373	96,696
1919	1,300	17	394	30	5,166	3,042	33,247
1920	268	*Nil.*	888	108	6,397	*Nil.*	225,773
1921	.....	570	*Nil.*	665	9,348	*Nil.*	191,224

Year.	Iron.				Nickel.	Pyrite.	Zinc.
	Pig and Scrap.	Bars and Hoops.	Nails and Spikes.	Steel.			
1908	6,787	2	4,839	17	*Nil.*	218,851	.....
1909	11,429	24	5,187	11	3	216,767	.....
1910	13,455	5	6,878	34	.....	343,073	.....
1911	12,569	40	5,692	271	385	343,350	.....
1912	16,889	.....	5,326	296	594	424,121	.....
1913	26,917	5	3,972	150	.....	460,912	10,538
1914	14,586	17	4,012	1,416	696	403,255	16,517
1915	12,961	.....	6,001	2,005	761	513,901	22,617
1916	(*d*)785	970	4,697	1,211	723	253,361	28,150
1917	(*d*)1,135	50	2,999	367	442	212,909	18,395
1918	(*d*)1,003	20	2,454	525	60	240,774	3,380
1919	(*d*)192	293	1,331	27	*Nil.*	118,588	3,950
1920	(*d*)4,542	447	3,563	44	53	273,500	11,187
1921	(*d*)567	*Nil.*	1,193	32	273	193,577	17,207

(a) From *Tabeller vedkommende Norges Bergvaerksdrift* and *Tabeller vedkommende Norges Handel.* (b) Includes flowers of sulphur. (c) Returns not available. (d) Pig and cast iron. (e) In metric tons. (f) Includes a quantity of sheet aluminium.

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PORTUGAL

The subjoined table reports the mineral production of Portugal:

MINERAL PRODUCTION OF PORTUGAL (a)

(In metric tons)

Year.	Antimony Ore.	Arsenic Ore.	Coal (Anthracite). (c)	Copper.			
				Copper-Iron Pyrite. (c)	Other Ores.	Cement.	Matte.
1905	84	1,562	11,449	352,479	210	2,148	(b)
1906	481	1,322	6,762	350,746	196	3,634	(b)
1907	383	1,538	8,824	241,771	2,478	2,942	298
1908	76	1,655	4,614	81,417	15,455	3,041	564
1909	6	1,420	6,274	12,337	1,321	3,037	309
1910	25	974	8,149	19,161	230	3,768	230
1911	.....	887	10,610	15,287	517	3,979	283
1912	100	1,006	15,626	120,148	1,309	4,028	.....
1913	19	925	25,037	13,550	.....	4,177	.....
1914	*Nil.*	960	29,680	40,850	219,140	3,200	.....
1915	.....	1,005	39,000	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....
1919	.....	62	146,341	52,404	390	2,298	.....
1920	.....	62	169,165	245,811	2,161	1,437	.....

Year.	Gold. *Kg.*	Iron Ore.	Lead Ore (Galena).	Manganese Ore	Sulphur Ore.	Tin Ore and Metal.	Tungsten Ore.
1907	10.5	(b)	510	1,374	123,393	35	226
1908	57.0	(b)	481	(b)	24,522	28	106
1909	25.0	(b)	736	(b)	272,398	18	673
1910	4.1	3,360	919	(b)	293,745	9	948
1911	3.6	19,541	1,185	6	267,486	26	903
1912	3.5	35,210	495	6	481,295	173	1,227
1913	1.0	61,168	1,046	(b)	384,798	254	1,089
1914	*Nil.*	9,008	2,163	(b)	72,224	370	912
1915	.....	14,365	.....	.....	177,857	298	1,390
1916	.....	2,225	.....	.....	.....	.....	1,550
1917	.....	7,264	.....	.....	.....	.....	1,160
1918	.....	.....	.....	.....	.....	.....	.....
1919	.....	8,712	118	193	.....	292	614
1920	.....	12,845	341	925	.....	181	218

(a) From reports specially furnished *The Mineral Industry* by the Chief of the Department of Mines of the Ministerio das Obras Publicas, except for 1904 to 1906, inclusive, and 1913 and 1914, which are from official Government reports. The mineral production of the country is identical with exports, except in the case of coal. (b) Not reported. (c) Consumed in the country. (d) Previous to 1907 the figures for "Sulphur Ore" (largely pyrite) were included under "Copper-Iron Pyrite."

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RUSSIA

The mineral and metallurgical production of Russia, according to the best statistics available to MINERAL INDUSTRY, is given in the subjoined tables.

MINERAL AND METALLURGICAL PRODUCTION OF RUSSIA (*a*)

(In metric tons; 1 metric ton = 61.05 poods)

Year.	Asbestos.	Chrome Ore.	Coal.	Copper.	Gold. (*b*)	Pig Iron.	Lead.	Manganese Ore.
1904..	7,502	26,575	19,608,631	9,835	$24,627,537	2,972,115	90.3	430,090
1905..	5,896	27,051	18,727,766	8,515	20,521,587	2,628,101	700.2	508,635
1906..	9,197	16,969	21,593,158	9,296	20,020,862	2,694,895	906.8	1,015,686
1907..	9,398	(*g*)26,357	25,741,321	15,930	26,518,253	3,041,570	520.0	(*g*)1,003,528
1908..	10,911	(*g*)10,950	(*g*)25,903,560	17,118	33,143,810	2,818,450	522.5	362,303
1909..	(*h*)13,129	22,213	24,532,349	19,656	31,889,956	2,889,353	.....	574,938
1910..	(*h*)10,936	1,362	(*f*)23,105,628	(*f*)22,619	(*f*) 35,566,045	(*f*)3,042,046	.....	668,050
1911..	17,071	1,238	28,007,239	(*f*)25,097	(*f*) 34,550,609	3,593,000	.....	(*i*) 636,180
1912..	18,138	21,277	30,641,163	33,513	28,852,881	3,726,000	.....	903,226
1913..	18,594	.....	32,206,000	34,282	22,199,000	3,801,273	.....	1,130,000
1914..	.....	.....	.....	32,250	24,300,000	.....	.....	652,354
1915..	.....	.....	.....	35,470	.....	2,792,516	.....	.....
1916.	.....	.....	.....	.....	.....	3,861,600	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....
1920..	1,480	2,960	.....	(*k*)3,750	.....	.....	.....	5,240
1921..	2,600	3,590	.....	(*k*)4,670	.....	.....	.....	12,800

Year.	Petroleum.	Phosphate Rock.	Platinum. *Kg.*	Pyrite.	Quicksilver.	Salt.	Silver *Kg.*	Sulphur.	Zinc.
1903..	9,759,214	14,635	6,009	22,780	362	1,658,938	1,152	281	9,894
1904..	10,058,968	20,282	5,016	31,667	332	1,908,275	726	16	10,612
1905..	7,505,637	20,585	5,250	30,689	318	1,844,678	2,965	16	7,911
1906..	8,167,934	18,970	5,776	20,660	210	1,730,934	430	39	9,602
1907..	9,098,931	(*g*)15,457	5,903	18,316	(*g*)132	1,873,171	7,843	(*d*)57	10,409
1908..	8,732,301	(*g*)14,976	4,883	56,345	147	1,879,717	9,595	(*d*)85	9,960
1909..	8,961,507	(*h*)21,326	5,120	(*f*)46,078	.....	2,259,690	(*h*)15,415	.....	7,644
1910..	8,952,793	(*h*)24,883	5,471	(*f*)55,980	.....	2,047,980	(*h*)14,841	.....	(*f*)8,631
1911..	9,152,315	(*h*)25,503	(*f*)5,432	113,054	.....	2,013,765	15,512	.....	(*f*)9,652
1912..	9,249,600	.....	5,523	123,990	.....	.....	.....	.....	8,763
1913..	9,474,876	.....	4,897	.....	.....	.....	.....	.....	7,610
1914..	9,099,494	.....	4,880	.....	.....	.....	.....	.....	.....
1915..	.....	.....	3,374	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1920..	.....	.....	.....	.....	.....	.....	.....	.....	.....
1921..	.....	.....	.....	6,360	.....	.....	.....	.....	(*k*)3,770

(*a*) From official sources. (*b*) The value of gold is taken at $20.67 per ounce. (*d*) Includes sulphide ore. (*f*) Statistics of Association of Russian Manufacturers and Traders. (*g*) St. Petersburg Scientific Committee. (*h*) The Russian Year Book, Dr. Kennard, London. (*i*) Exports. (*j*) *Mineral Resources of U. S.* (*k*) Ore.

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SOUTH AMERICA

The following tables itemize the statistics of the production and the foreign commerce, or both, of mineral and metallurgical products of South American countries so far as available. No statistics later than those given in the tables have been published. Figures in full-faced type are either provisional figures or estimates.

MINERAL AND METAL PRODUCTION OF BOLIVIA (*a*)

(In metric tons)

Year.	Antimony Ore.	Bismuth.		Copper Ore.	Copper. (*c*)	Gold. (*b*)	Silver. (*d*)	Tin Ore.	Tungsten Ore.
		Metal.	Ore.						
1910....	.....	97	311.060	.....	3,212	.....	143	38,548	207
1911....	312	(*g*)415	1,208.689	.....	2,950	$ 22,313	128.0	37,073	297
1912....	91	(*g*)478	.....	.....	4,707	23,038	123.9	38,614	472
1913....	62	391	32	.....	4,020	175,000	81.3	44,597	283
1914....	186	(*g*)437	.....	4,793	3,874	.....	72	37,259	276
1915....	17,923	(*g*)663	.....	17,945	5,839	.....	78	36,324	755
1916....	27,414	(*g*)680	.....	23,860	5,151	.....	.....	35,543	3,035
1917....	23,370	255	279	32,135	5,310	.....	14,657	46,430	3,891
1918(*f*)..	6,849	145	116	26,000	2,341	.....	57	48,800	3,418
1919(*f*)..	238	169	132	9,876	3,015	4,650	75.7	48,211	1,995
1920....	1,100	195	180	15,754	1,981	4,650	68.4	46,942	708

(*a*) From a British Consular report and Revista de Aduanas. (*b*) Reduced to U. S. currency. (*c*) Includes ingots, precipitate, matte and concentrate. (*d*) Includes ingots, ore, and sulphide. (*f*) Exports. (*g*) Metal and metal content of ore.

MINERAL EXPORTS OF BRAZIL (*a*)

(In metric tons or dollars) (*d*)

Year.	Agate.	Carbonado. *Carats*	Copper Ore.	Diamonds. *Carats.*	Gold.	Manganese Ore.	Mica	Monazite.	Platinum	Precious Stones. (*b*)	Rock Crystal.
1909(*e*)	.....	177,572	(*c*)	58,862	$2,252,900	240,774	.....	6,462	*Nil*	$56,338	.....
1910(*e*)	34	13,848	(*c*)	14,366	1,954,674	253,953	1.4	5,437	*Nil*	745	.....
1911(*e*)	112	63,400	1	103,567	2,850,370	173,941	9.0	371	*Nil*	135,220	24
1912(*e*)	103	47,998	.....	139,175	2,676,950	154,870	11.5	3,398	*Nil*	74,597	45
1913..	97	17,189	360	.....	2,692,154	122,300	.....	1,437	*Nil*	174,066	43
1914..	.....	.....	.....	.....	2,127,515	183,600	15.3	600	*Nil*	21,022	.....
1915(*e*)	.....	$119,994	.....	11,803	2,390,719	288,671	11.9	439	*Nil*	44,024	14
1916(*e*)	.....	457,941	.....	84,004	2,909,292	503,130	53.7	*Nil.*	$4,003	116,784	20
1917..	0.6	417,704	.....	810,389	2,901,534	532,855	96.6	1,136	.....	.....	3
1918..	0.3	1,168.392	.....	1,369,948	.....	393,388	161	500	.....	.....	12
1919..	0.4	605,957	.....	1,365,372	2,000,000	205,725	154	146	.....	109,343	27
1920..	33	633,926	105	1,083,528	1,800,000	453,737	68	1.153	*Nil.*	110,148	40
1921..	72	449,410	*Nil.*	778,073	.....	275,694	46	332	*Nil.*	131,548	41

(*a*) As reported by the *Brasilian Review*. (*b*) Other than carbonado and diamonds. (*c*) Statistics not available. (*e*) Reported by U. S. Consul at Rio de Janeiro.

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MINERAL PRODUCTION OF CHILE (a)

(In metric tons)

Year.	Borax.	Coal.	Iron Ore.	Copper.	Gold. Kg.	Guano.	Iodine.	Salt.	Silver. Kg.	Sodium Nitrate.	Sulphur.
1907..	28,374	832,612	.....	28,863	1,907	7,518	4,202	18,982	18,736	1,846,036	2,905
1908..	35,039	939,836	.....	42,097	1,189	871	330	16,257	43,569	1,970,974	2,705
1909..	32,218	898,971	.....	42,726	1,268	10,692	474	20,463	35,907	2,110,961	4,508
1910..	35,192	1,074,174	.....	38,232	1,088	12,683	581	23,361	34,958	2,465,415	3,823
1911..	45,558	1,188,053	28,600	36,420	437	17,841	437	23,720	27,675	2,521,023	4,451
1912..	43,356	1,334,407	6,651	41,647	1,101	18,266	458	17,045	30,178	2,585,850	4,431
1913..	50,225	1,283,450	14,100	42,264	1,147	11,718	437	19,558	39,564	2,722,254	6,647
1914..	31,907	1,086,946	63,505	44,665	1,077	20,594	489	24,805	36,581	2,463,356	10,008
1915..	14,869	1,171,564	147,100	52,340	1,336	11,994	709	30,266	40,445	1,755,291	9,769
1916..	12,565	1,418,119	56,166	71,288	1,462	17,972	1,221	30,785	47,440	2,912,893	14,879
1917..	11,963	1,539,314	5,000	102,527	1,900	15,785	737	37,694	53,393	3,001,032	18,942
1918..	6,603	1,516,524	*Nil.*	106,813	1,939	15,000	1,079	54,536	47,232	2,859,303	19,557
1919..	10,116	1,485,491	748	79,580	1,984	.....	505	29,454	41,356	1,703,240	18 910
1920..	15,823	1,063,185	3,100	98,951	1,654	18,874	350	33,951	81,008	2,523,458	13,340

(a) From *Estadistica Minera de Chile.* (b) The combined output of the years 1894 to 1902, inclusive was 86,892 tons.. (c) The combined output of Chile up to the end of 1902 is estimated at 20,650,000 tons. (e) Exports. (f) The combined output of Chile up to the end of 1902 is estimated at 163,704 tons, valued at 5,041.560 pesos ($1,840,169).

MINERAL AND METAL PRODUCTION OF PERU (a)

(In metric tons)

Year.	Bismuth.	Borate.	Coal. (b)	Copper.	Gold. Kg.	Lead.	Petroleum.	Quicksilver. Kg.	Silver. Kg.	Salt.	Tungsten Ore.	Vanadium Ore.
1911...	24	1,923	324,000	27,735	741.2	2,208	195,276	560	289,383	24,867	48	.....
1912...	51	1,674	278,927	26,970	1,435.0	4,050	233,600	400	324,352	23,292	195	.....
1913...	25	2,001	273,945	27,776	1,435.0	3,927	276,147	460	299,132	24,433	290	.....
1914...	11	1,263	283,860	27,090	1,500.0	3,048	252,666	700	286,600	25,933	196	14
1915...	.....	510	290,743	34,727	1,690.0	2,696	363,162	920	294,425	25,729	375	3,145
1916...	.....	1,289	319,063	43,078	1,907.0	2,038	345,758	2,101	335,529	26,069	523	3,448
1917...	1	800	353,595	45,176	1,887.0	1,272	347,092	1,500	337,928	27,073	406	4,083
1918...	.....	523	346,226	44,414	1,793.0	632	335,002	1,500	304,253	26,663	243	2,183
1919...	.....	519	344,260	39,230	2,029.0	1,066	348,649	.....	305,497	27,724	129	2,974
1920...	8	261	377,237	32,982	1,952. 0	562	373,280	.....	286,043	27,172	69	9,700

(a) Reported by the Cuerpo de Ingenieros de Minas del Peru, in its *Bolstin.* (b) Includes asphaltum and bituminous schist.

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SPAIN

The following tables record the mineral and metal production of Spain as reported by official authorities:

MINERAL PRODUCTION OF SPAIN (*a*)

(In metric tons)

Year.	Aluminous Earths.	Antimony Ore.	Arsenic.	Asphaltum. (Refined)	Asphalt, Rock. (*d*)	Barytes.	Bismuth Ore.	Cement, Hydraulic.	Coal.	
									Anthracite.	Bituminous.
1907..	1,209	205	1,500	8,643	8,219	314	.....	329,926	164,498	3,531,337
1908..	60	124	2,004	9,231	12,373	234	.....	343,001	188,463	3,696,653
1909..	35	(*b*)	506	6,582	5,284	422	78	472,909	198,302	3,602,573
1910..	440	15	444	8,478	(*b*)	476	53	484,161	211,958	3,600,056
1911..	461	160	331	3,495	(*b*)	635	52	486,065	209,227	3,454,396
1912..	508	500	(*b*)	6,087	(*b*)	1,006	73	525,319	226,663	3,625,664
1913..	288	(*b*)	(*b*)	5,695	(*b*)	3,049	56	511,961	232,517	3,783,210
1914..	249	(*b*)	(*b*)	4,143	5,765	2,474	40	473,764	228,302	3,905,089
1915..	314	300	(*b*)	2,671	4,521	4,218	17	476,255	222,621	4,135,915
1916..	256	515	(*b*)	2,591	7,316	10,508	11	536,246	268,093	4,847,473
1917..	470	502	(*b*)	1,950	(*b*)	10,147	14	462,357	324,756	5,042,216
1918..	286	80	104	2,367	8,295	4,170	34	401,117	377,216	6,134,989
1919..	227	.....	42	2,385	10,091	11,459	75	363,460	398,771	5,304,864
1920..	219	.....	76	.....	.....	12,733	53	490,816	491,715	4,928,966

Year.	Coal (*Continued*).		Coke.	Copper Ore. (*c*)	Copper.				Fire Clay.	Fluorspar.	Graphite.
	Lignitic.	Briquets.			Blister.	Matte.	Precipitate.	Sulphate.			
1907.....	191,001	355,718	476,360	3, 82,645	(*b*)	9 886	20,887	.....	.....	270	.....
1908.....	223,160	296,216	477,059	2,985,779	(*b*)	205	19,599	.....	.....	253	.....
1909.....	265,019	(*b*)	500,909	2,955,254	15,442	2,077	16,641	.....	150	246	.....
1910.....	245,518	474,891	521,078	3,231,418	14,703	2,684	14,056	.....	159	180	.....
1911.....	252,051	478,143	516,342	3,284,184	16,385	1,910	12,353	.....	613	499	.....
1912.....	283,480	465,106	489,558	3,364,294	20,638	1,861	15,044	.....	6,466	265	.....
1913.....	276,791	486,228	595,677	2,268,601	20,889	3,049	7,260	.....	6,250	351	.....
1914.....	291,057	558,329	597,315	1,502,599	(*f*)13,335	.....	10,371	532	986	79	.....
1915.....	328,213	555,257	622,353	1,480,412	20,224	2,001	12,374	1,126	5,570	370	30
1916.....	473,106	555,975	759,754	1,773,922	(*f*)20,769	.....	12,111	7,600	6,302	277	1,240
1917.....	637,341	449,447	542,767	1,901,341	(*f*)25,557	.....	12,969	10,414	4,245	250	1,980
1918.....	726,248	400,728	630,210	1,007,708	20,063	1,600	23,441	8,603	1,215	350	710
1919.....	530,572	.....	331,000	1,470,0914	10,216	.....	10,951	7,988	.....	280	1,958
1919.....	552,425	.....	280,717	863,193	9,790	.....	11,168	.....	.....	416	6,315

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Year.	Iron Ore.		Iron and Steel.			Kaolin (China Clay).	Lead (Argentiferous).	
	Argentiferous.	Non-argentiferous.	Pig.	Wrought Iron.	Iron and Steel, Worked.		Ore.	Metal
1907...	(b)	9,896,178	355,240	14,767	310,125	640	165,289	51,430
1908...	(b)	9,271,592	403,554	21,807	262,843	1,370	165,382	53,741
1909...	3,813	8,786,021	428,622	24,187	242,596	570	161,496	43,552
1910...	46,161	8,666,795	373,322	59,133	260,931	1,496	150,592	38,548
1911...	(b)	8,773,691	408,667	11,166	286,260	4,469	156,569	40,379
1912...	1,588	9,133,007	403,243	(h)	297,366	4,920	93,850	49,212
1913...	(b)	9,861,668	.....	(h)	(g)666,769	5,263	23,600	(i)
1914...	(b)	6,819,964	(h)	(h)	(g)382,044	4,870	22,373	(i)
1915...	(b)	5,617,839	(h)	(h)	(g)387,314	4,700	2,935	(i)
1916...	(b)	5,856,861	497,726	(h)	322,931	1,500	7,371	(i)
1917...	(b)	5,551,071	357,699	(h)	470,242	1,220	13,218	(i)
1918...	.....	4,692,651	386,550	(h)	303,206	2,000	3,505	(i)
1919...	.....	4,640,061	294,167	(h)	241,189	34	41,875	24,177
1920...	.....	4,767,693	251,413	(h)	.....	950	10,527	.....

Year.	Lead (Non-argentiferous).		Magnesite.	Manganese Ore.	Mineral Paints (Ocher).	Phosphate Rock.	Pyrite (Iron).	Pyrite (Arsenical).	Quicksilver.	
	Ore.	Metal.							Ore.	Metal.
1907....	103,632	135,066	.....	41,504	114	3,547	225,830	3,423	28,789	1,212
1908....	126,667	134,321	.....	16,745	400	4,483	263,451	5,533	42,210	1,068
1909....	137,050	136,441	850	7,827	418	1,387	258,931	3,235	37,298	1,393
1910....	216,738	151,975	1,277	8,607	759	2,840	294,184	1,461	22,714	1,114
1911....	165,843	149,540	1,400	5,607	622	3,520	344,879	1,056	19,940	1,494
1912....	190,162	183,400	1,480	17,400	600	3,292	421,070	(b)	21,898	1,256
1913....	279,078	(j)198,829	958	21,594	600	3,548	926,913	(b)	19,960	1,946
1914....	246,221	(j)143,524	583	8,965	1,500	8,312	984,885	(b)	17,714	953
1915....	285,266	(j)171,472	1,400	14,328	1,500	9,080	802,383	(b)	20,717	1,222
1916....	260,283	(j)147,407	2,500	14,178	800	14,111	953,679	(b)	19,799	795
1917....	240,368	(j)172,909	800	57,474	780	28,148	976,918	(b)	18,705	827
1918....	216,133	(j)169,709	1,700	77,714	700	43,303	590,008	250	17,537	567
1919....	136,180	(j)125,721	120	66,685	680	25,035	431,189	150	24,966	1,226
1920...	175,976	(j)175,196	1,214	21,256	301	42,896	711,823	1,000	17,480	862

Year.	Salt.	Silver.		Soapstone.	Sodium Sulphate.	Sulphur.		Tin Ore, Dressed.	Topas, Kg.	Tungsten Ore.	Zinc.		
		Ore.	Metal. Kg.			Crude Rock.	Refined.				Ore.	Spelter.	Sheets.
1907.....	605,895	702	127,435	13,875	.....	27,054	3,612	315	266	386	191,853	6,144	2,485
1908.....	822,677	441	129,881	4,730	.....	13,872	2,988	338	(b)	226	156,233	6,357	2,693
1909.....	823,747	388	143,403	5,583	141	21,750	3,429	( )1,555	(b)	129	163,522	2,526	6,102
1910.....	678,057	217	129,157	4,665	410	30,113	3,834	35	149	153	156,113	2,722	7,017
1911.....	679,947	358	110,082	5,647	411	40,662	6,580	34	(b)	96	162,140	3,429	2,904
1912.....	650,047	668	143,439	4,635	570	42,344	4,592	5,079	(b)	169	175,211	3,076	4,067
1913.....	610,429	405	125,394	4,407	293	62,653	7,499	6,616	(b)	235	117,831	2,691	3,312
1914.....	927,767	496	134,515	4,612	363	47,180	8,060	877	(b)	437	114,317	2,963	8,780
1915.....	793,340	210	142,003	963	191	28,937	9,670	102	(b)	511	81,922	8,117	
1916.....	895,928	275	140,521	3,561	1,900	46,923	10,629	86	(b)	455	166,053	8,533	
1917.....	781,106	96	114,342	3,450	875	84,979	12,885	77	(b)	546	123,845	10,155	
1918.....	320,531	962	98,988	3,328	3,697	72,360	12,738	71	(b)	4,555	106,958	15,900	
1919.....	481,921	77	82,931	3,024	3,230	89,586	11,445	154	(b)	337	103,608	16,214	
1920.....	991,545	.....	91,961	2,146	299	77,039	12,693	144	(b)	62	94,051	9,647	

(a) Figures are from *Estadistica Minera de España*. (b) Not reported. (c) Includes copper pyrite. (d) Includes bituminous rock and crude asphalt. (e) Undressed tin ore. (f) Includes copper matte (g) Includes pig iron. (h) Included in Iron and Steel, Worked. (i) Not reported separately; included with non-argentiferous lead. (j) Includes argentiferous lead.

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SWEDEN

The official statistics of mineral production, imports and exports, are summarized in the following tables:

MINERAL PRODUCTION OF SWEDEN (a)
(In metric tons)

Year.	Alum.	Coal.	Copper.			Feldspar.	Graphite.	Gold. *Kg.*
			Ore.	Ingot.	Sulphate.			
1908.....	138	305,206	21,371	2,808	731	17,494	66	20.3
1909.....	132	246,808	9,562	2,375	628	15,772	26	14.1
1910.....	182	302,786	3,638	3,111	20	21,591	49	1.8
1911.....	159	311,809	1,623	3,221	320	36,235	65	11.0
1912.....	145	360,291	3,059	3,957	870	34,305	79	30.6
1913.....	159	363,965	5,458	4,315	428	37,878	88	25.4
1914.....	.....	366,639	8,839	4,692	651	20,818	56	84.3
1915.....	.....	412,261	10,549	4,561	.....	12,105	87	37.3
1916.....	.....	414,825	13,895	3,181	1,268	12,724	194	18.2
1917.....	.....	442,633	13,579	4,423	956	18,533	123	11.1
1918.....	.....	404,494	21,408	2,956	.....	17,850	.....	15.0
1919.....	.....	429,267	7,279	3,558	.....	12,905	.....	21.6
1920.....	.....	439,584	1,136	1,289	.....	12,049	7	7.0

Year	Iron and Steel.					Steel.		
	Ore.	Pig.	Blooms, Unwelded.	Bars, Rods, etc.	Iron Sulphate.	Bessemer.	Martin.	Crucible and Electro.
1908....	4,712,494	567,821	152,256	390,957	277	81,054	355,394	1,169
1909....	3,885,046	444,764	120,669	308,823	182	63,351	248,757	1,518
1910....	5,549,987	603,939	151,713	431,722	236	97,583	372,451	2,215
1911....	6,150,718	634,392	146,722	423,170	156	93,853	372 705	4,309
1912....	6,699,226	699,816	148,828	470,352	335	107,254	307,637	3,941
1913....	7,475,571	730,257	158,472	516,561	320	115,839	404,118	5,661
1914....	6,586,630	639,718	116,074	441,060	158	93,210	469,337	4,594
1915....	6,883,308	760,701	119,629	537,922	.....	91,070	503,766	5,582
1916....	6,986,293	732,734	119,197	526,353	279	75,800	525,500	9,388
1917....	6,217,172	828,969	114,429	487,587	146	77,854	491,257	11,889
1918....	6,623,661	761,822	92,823	426,473	.....	66,155	465,016	14,431
1919....	4,981,110	493,701	63,629	381,541	.....	57,593	420,547	13,148
1920....	4,519,112	470,550	60,516	361,249	.....	53,340	370,232	13,944

Year.	Lead.	Manganese Ore.	Pyrite.	Silver-Lead Ore.	Silver. *Kg.*	Nickel Ore.	Zinc Ore.
1908.....	277	4,616	29,569	2,058	630	.....	40,077
1909.....	166	5,212	16,104	1,721	512	.....	43,760
1910.....	355	5,752	25,445	2,700	30	.....	49,453
1911.....	1,134	5,377	30,096	2,999	1,289	.....	51,242
1912.....	1,073	5,101	31,835	2,877	962	.....	50,036
1913.....	1,235	4,001	34,319	3,222	1,037	.....	50,752
1914.....	1,396	3,643	33,313	3,110	1,074	156	42,279
1915.....	1,918	7,607	76,324	2,671	754	1,642	55,937
1916.....	2,076	8,894	97,848	3,707	1,180	3,561	60,700
1917.....	3.174	19,873	142,660	3,709	1,784	4,991	51,312
1918.....	2,241	16,570	141,181	3,170	980	2,480	48,507
1919.....	827	12,278	108,770	1,671	620	416	49,451
1920.....	863	14,926	107,326	2,901	359	*Nil.*	47,674

(a) From *Sveriges Officiella Statistik Bergshanteringen.*

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MINERAL IMPORTS OF SWEDEN (a)

(In metric tons or dollars; 1 krona = 27 cents)

Year.	Asbestos. (c)	Asphalt.	Barytes.	Borax.	Boric Acid.	Bromine and Bromides. Kg.	Cement.	Chalk, White, Unground.	Coal.
1907....	672	8,213	610	490	85	6,784	17,801	860	4,146,785
1908....	505	6,368	514	347	71	11,499	6,158	419	4,427,507
1909....	383	7,922	529	365	76	10,280	12,944	512	4,084,055
1910....	671	7,406	625	379	92	10,913	15,438	473	4,180,250
1911....	1,011	6,803	607	381	76	16,819	24,830	605	3,964,870
1912....	635	7,645	644	434	100	9,319	17,438	422	4,293,719
1913....	1,094	6,809	610	470	120	11,211	12,120	2,337	4,878,854
1914....	789	7,348	730	462	137	21,064	14,769	2,332	4,626,932
1915....	895	10,567	1,665	825	211	14,904	15,579	4,769	3,836,097
1916....	896	6,331	3,308	499	72	17,792	15,685	732	4,027,141
1917....	70	4,287	755	176	47	8,652	5,221	.....	1,500,425
1918....	265	4,716	1,443	73	36	17,958	5,810	.....	1,926,711
1919....	759	6,106	355	605	143	46,714	4,398	.....	1,930,614
1920....	770	4,766	959	499	122	43,241	4,592	.....	2,811,736
1921....	258	3,969	416	174	97	28,211	20,387	.....	1,458,334

Year.	Copper, also Alloys of Copper.	Emery.	Graphite.	Gypsum.	Pig Iron and Scrap.	Lead. (c)	Litharge.	Phosphorus. Kg.	Platinum. Kg. (c)
1907....	6,945	336	375	15,037	115,174	3,384	210	77,936	109
1908....	6,849	308	540	11,644	109,837	3,964	248	107,301	117
1909....	5,639	428	443	14,212	99,510	3,223	217	88,241	72
1910....	9,710	438	398	15,816	118,373	3,453	267	99,145	77
1911....	8,817	459	398	14,505	114,837	2,901	270	77,837	103
1912....	7,767	474	513	19,237	140,145	3,019	316	88,411	84
1913....	10,265	655	576	23,222	172,489	3,394	327	92,487	126
1914....	13,557	495	334	13,210	163,290	3,022	474	140,040	90
1915....	14,901	915	851	9,244	166,026	2,296	538	176,650	282
1916....	12,642	1,398	719	14,353	194,100	5,945	677	103,726	234
1917....	3,715	662	668	9,427	82,615	135	41	21,187	199
1918....	4,031	573	521	11,729	40,943	1,001	33	54,430	76
1919....	14,639	420	376	4,896	78,997	2,653	372	38,367	18
1920....	18,178	312	501	14,182	97,430	4,039	537	99,554	30
1921....	7,157	231	228	6,731	23,577	1,584	417	54,557	33

Year.	Potassium.				Quicksilver. Kg.	Salt.		Silver.	
	Chloride.	Cyanide. Kg.	Hydrate.	Carbonate.		Crude. (h)	Refined.	Bullion and Mfrs. Kg.	Specie.
1907.....	1,840	4,150	2,484	1,269	8,930	835,190	18,821	26,834	$52,463
1908.....	2,190	3,563	2,835	1,209	7,299	903,633	24,394	20,149	94,368
1909.....	1,805	3,808	2,627	1,312	6,077	766,195	24,143	17,495	154,265
1910.....	2,335	4,272	2,767	1,346	7,079	766,512	22,425	21,162	75,604
1911.....	1,288	4,993	3,737	1,268	4,164	736,935	26,026	15,175	135,410
1912.....	2,541	(d) 7,545	(e)3,262	1,380	5,110	1,049,670	22,009	21,220	144,491
1913.....	2,081	(d) 7,607	(e)5,234	1,417	5,142	914,371	24,927	20,550	68,752
1914.....	2,640	(d) 4,634	(e)5,127	1,644	5,823	969,926	25,119	29,356	57,963
1915.....	3,407	(d)10,599	(e)5,779	1,596	13,714	990,857	20,568	40,689	391,857
1916.....	4,431	(d)13,105	(e)8,664	2,730	15,905	1,435,202	28,026	41,407	.....
1917.....	1,845	(d)14,504	(e)1,439	1,778	16,604	1,207,490	21,650	66,420	.....
1918.....	1,302	(d) 8,612	(e) 807	410	3,802	1,115,935	22,993	19,371	.....
1919.....	459	(d)32,753	(e)5,262	2,204	27,977	359,544	14,325	25,131	.....
1920.....	6,058	(d)44,230	(e)5,375	1,909	27,976	719,676	27,512	30,084	.....
1921.....	128	(d)30,901	(e)4,224	694	4,894	561,493	26,844	18,105	.....

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Year.	Sodium.				Sulphur.	Sulphuric Acid.	Tin.		Zinc and Mfrs.
	Carbonate. (i)	Hydrate.	Nitrate.	Sulphate. (f)			Salts. Kg.	Block and Scrap.	
1908....	14,149	1,256	27,631	18,717	30,806	3,073	2,817	808	4,626
1909....	13,490	1,119	28,894	20,226	26,836	1,955	1,357	794	5,294
1910....	15,594	1,260	32,340	22,429	38,530	2,707	1,161	764	5,843
1911....	15,777	2,501	31,324	27,482	34,622	861	915	866	5,951
1912....	18,255	.....	35,107	26,540	38,471	593	(k)73,045	1,032	6,975
1913....	18,473	.....	33,891	31,740	39,715	1,114	(k)56,982	1,083	6,114
1914....	18,698	.....	41,657	32,401	36,054	455	(k)55,931	1,482	7,835
1915....	21,622	.....	30,913	42,615	26,431	36	(k)54,423	4,240	9,762
1916....	14,983	.....	36,360	57,571	26,884	1	(k)29,816	998	9,993
1917....	3,829	.....	17,178	46,298	14,618	*Nil.*	(k)17,253	308	7,075
1918....	2,415	.....	6,763	36,733	19,867	1	*Nil.*	387	874
1919....	14,217	.....	23,212	13,475	22,297	130	16,496	998	10,635
1920....	18,601	.....	23,049	50,338	57,659	600	28,211	1,284	5,280
1921....	8,864	.....	26,051	14,079	21,038	655	16,699	729	2,487

MINERAL EXPORTS OF SWEDEN (a)

(In metric tons or dollars; 1 krona = 27 cents)

Year.	Alum.	Ammonium Sulphate.	Antimony, Crude. Kg.	Asbestos, Kg. (c)	Cement.	Coal (Anthracite).	Copper.		Graphite.
							Ore.	Copper and Alloys.	
1906 ...	11	30	4,584	1,510	45,960	1,352	1,841	2,595	12
1907 ...	7	*Nil.*	4,485	5,608	18,053	2,925	882	1,933	8
1908 ...	9	202	4,188	1,412	34,164	1,293	1,114	2,493	18
1909 ...	5	331	6,536	1,093	33,197	771	723	2,152	7
1910 ...	11	704	4,555	1,242	73,351	776	878	2,580	7
1911 ...	2	253	7,320	760	108,653	1,045	1,114	2,500	12
1912 ...	15	42	9,151	564	127,142	4,952	1,577	4,273	9
1913 ...	6	254	6,803	1,066	137,074	1,443	1,709	3,495	48
1914 ...	18	90	12,752	1,743	39,347	326	1,352	8,039	133
1915 ...	143	5,583	31,680	2,424	61,116	5	3,346	4,210	165
1916 ...	120	1	36,695	.....	77,717	1	2,278	4,654	8
1917 ...	135	.....	.....	29,161	4,651	3,741	.....	2,007	3
1918 ...	196	.....	.....	7,515	6,236	1,705	.....	.....	.....
1919 ...	.....	.....	.....	.....	37,200	.....	.....	2,976	.....
1920 ...	65	5,808	.....	93,285	68,131	8,492	*Nil.*	1,781	47
1921 ...	6	2,377	.....	54,050	29,008	6,883	1,390	7,854	7

Year.	Gypsum and Mfrs.	Iron and Steel.		Lead. (c)	Peat.	Phosphorus. Kg.	Potassium Chlorate.
		Ore.	Pig-Iron and Scrap.				
1906.....	6	3,661,218	126,283	532	6,531	700	857
1907.....	16	3,521,717	139,466	519	6,524	(b)	1,753
1908.....	37	3,654,268	112,522	496	5,559	400	1,364
1909.....	21	3,196,453	112,793	319	9,999	1,305	1,400
1910.....	41	4,413,600	143,522	557	9,754	265	1,383
1911.....	13	5,086,898	158,328	1,181	10,371	595	1,564
1912.....	2	5,520,653	213,619	1,003	7,276	600	1,653
1913.....	1	6,439,750	216,013	745	7,135	900	1,423
1914.....	48	4,787,314	181,784	414	8,981	19,025	1,591
1915.....	549	5,992,970	304,465	568	26,313	102,563	(l) 1,312
1916.....	184	5,539,580	231,216	360	20,212	2,927	695
1917.....	265	5,613,148	231,669	465	3,973	.....	1,132
1918.....	393	4,479,970	180,116	155	2,414	4,000	648
1919.....	.....	5,818,498	81,263	130	.....	.....	871
1920.....	18	3,728,623	120,338	284	1,724	705	2,785
1921.....	*Nil.*	4,331,046	88,911	1,884	2,536	2,500	1,269

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Year.	Salt, Refined. *Kg.*	Silver Bullion. *Kg.*	Sodium Carbonate. (i)	Sulphur.	Tin.		Zinc.	
					Block and Scrap.	Mfrs. *Kg.*	Ore.	Crude and Mfrs.
1906....	8,652	77	13	12	51.0	353	45,380	410
1907....	4,452	160	39	1	67.9	2,518	41,236	529
1908....	14,300	136	114	7	54.0	274	38,543	908
1909....	6,422	437	27	5	42.5	256	38,865	1,200
1910....	1,326	814	31	6	51.1	356	40,405	1,278
1911....	3,450	1,090	40	7	66.1	152	41,854	2,158
1912....	1,668	2,021	3	76	109.8	698	41,985	3,136
1913....	6,916	4,300	2	239	86.6	2,640	46,696	6,533
1914....	495,839	4,456	30	80	517.4	3,985	41,499	6,333
1915....	4,062,100	8,972	456	759	3,431.0	13,526	42,157	8,327
1916....	.....	14,537	53	.....	35.6	6,490	9,351	5,788
1917....	.....	8,772	.....	1	28.9	929	6,329	6,417
1918....	.....	5,647	.....	.....	22.9	172	16,210	826
1919....	.....	.....	.....	.....	40.4	.....	55,138	1,985
1920....	.....	.....	339	2,809	43.2	.....	71,298	1,863
1921....	.....	.....	453	880	161.3	.....	29,385	4,833

(*a*) From *Sveriges Officiella Statistik Handel.* (*b*) Not reported. (*c*) Includes crude and manufactures. (*d*) Includes sodium cyanide. (*e*) Includes sodium and potassium. (*f*) Includes sodium bisulphate. (*g*) Metric tons. (*h*) Hectoliters. (*i*) Includes bicarbonate. (*k*) Includes tin chloride and tin oxide. (*l*) Includes sodium chlorate.

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UNITED KINGDOM

The statistics of the mineral production, imports and exports, according to official reports, are given in the subjoined tables. Figures given in full-faced type are either provisional figures or estimates.

MINERAL AND METALLURGICAL PRODUCTION OF THE UNITED KINGDOM (*a*)
(In metric tons)

Year.	Alum Shale.	Arsenious Acid.	Arsenical Pyrites.	Barium Minerals.	Bauxite.	Chalk.	Clay. (*c*)	Coal.
1908....	5,459	2,007	3,270	39,572	11,904	4,329,983	14,638,710	265,726,332
1909....	9,266	2,926	182	42,436	9,652	4,508,136	14,293,598	268,007,890
1910....	6,781	2,187	958	45,384	4,208	4,705,766	(*b*)14,316,469	268,677,182
1911....	10,685	2,178	1,189	44,826	6,103	5,965,423	14,057,090	276,255,764
1912....	11,446	2,228	1,806	43,453	5,882	4,962,408	13,022,433	264,749,661
1913....	8,887	1,716	36	48,792	6,153	4,939,095	14,090,818	292,047,544
1914....	6,179	2,007	(*b*)	49,718	8,421	4,362,689	13,343,100	270,070,414
1915....	8,038	2,537	428	63,483	11,914	3,285,963	9,014,657	257,282,699
1916....	6,362	2,586	305	77,258	10,495	2,831,181	6,605,044	260,503,009
1917....	5,644	2,668	384	66,612	14,961	2,300,806	5,936,742	252,500,078
1918....	5,315	2,387	465	67,428	9,743	2,341,346	6,100,448	231,380,784
1919....	4,926	2,568	76	61,054	9,369	2,671,739	7,890,997	233,441,992
1920....	5,628	2,029	1,197	65,183	11,197	3,807,494	11,208,008	233,227,547

Year.	Copper.		Fluorspar.	Gold.		Gravel and Sand.	Gypsum.	Bog Ore (Ireland). (*c*)
	Ore and Precipitate.	Fine.		Ore.	Bullion. *Kg.*			
1908.....	5,528	588	35,257	7,237	28.5	2,228,245	231,930	4,364
1909.....	3,777	442	43,165	5,627	37.6	2,199,583	242,832	2,719
1910.....	4,245	456	62,607	6,252	75.5	2,235,160	259,661	2,603
1911.....	3,314	398	56,117	2,796	13.2	2,311,694	281,125	2,743
1912.....	1,942	296	29,154	173	49.7	2,227,975	247,724	3,397
1913.....	2,108	428	54,557	4	4.9	2,449,305	242,341	3,899
1914.....	2,561	347	34,360	55	3.2	2,540,520	269,637	2,381
1915.....	835	238	33,656	5,169	39.1	2,388,106	251,209	2,018
1916.....	1,045	282	55,612	1,360	8.5	1,993,233	222,814	1,113
1917.....	1,178	190	65,918	*Nil.*	*Nil.*	1,960,224	175,800	1,765
1918.....	1,186	203	54,359	*Nil.*	*Nil.*	2,055,130	205,513	613
1919.....	378	146	37,453	*Nil.*	*Nil.*	2,081,417	208,141	3,094
1920.....	82	109	55,563	1	1.1	2,801,441	291,598	2,214

Year.	Iron.		Lead.		Manganese Ore.	Mineral Paints.	Oil Shale.	Phosphate of Lime.
	Ore.	Pig.	Ore.	Pig.				
1908....	15,272,273	4,925,250	29,718	21,336	6,409	15,643	2,938,456	9
1909....	15,220,408	(*f*)9,818,916	30,221	22,823	2,812	16,575	3,014,678	4
1910....	15,470,392	5,055,595	28,992	21,867	5,554	16,782	3,180,520	*Nil.*
1911....	15,768,511	5,101,089	24,186	18,279	5,067	14,819	3,166,838	.....
1912....	8,552,343	4,525,830	25,729	19,473	4,237	14,179	3,235,942	.....
1913....	16,263,950	5,224,607	24,656	18,462	5,480	15,387	3,333,048	.....
1914....	15,115,375	4,865,858	26,422	19,684	3,494	11,247	3,321,291	.....
1915....	14,464,196	4,640,885	21,078	15,770	4,716	9,134	3,046,930	.....
1916....	13,811,920	4,388,633	17,382	12,775	5,962	10,323	3,057,680	.....
1917....	15,084,750	(*f*)9,572,190	15,569	11,431	10,102	.....	3,167,852	.....
1918....	14,848,302	(*f*)9,184,974	15,003	11,084	17,737	5,275	3,126,387	3,426
1919....	12,451,406	(*f*)7,517,108	14,067	10,442	12,272	5,615	2,803,588	.....
1920....	12,912,065	(*f*)8,086,311	15,647	9,940	13,082	15,198	2,888,348	.....

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Year.	Pyrite.	Salt.	Silica (Chert and Flint).	Silver. *Kg.*	Stone.			
					Igneous Rock.	Limestone. (*d*)	Sandstone.	Slate.
1908.....	9,600	1,873,555	64,813	4,207	6,211,860	11,977,007	5,105,481	420,979
1909.....	8,964	1,851,999	53,063	4,421	6,384,144	12,000,790	4,673,839	408,639
1910.....	10,393	2,083,543	75,089	4,251	6,714,774	12,713,565	4,456,679	423,006
1911.....	10,276	2,116,115	72,726	3,684	6,629,417	12,378,725	4,109,828	431,948
1912.....	10,691	2,157,621	75,963	3,955	6,748,852	11,692,338	3,903,560	389,812
1913.....	11,611	2,285,221	76,105	4,439	7,216,801	12,953,008	4,043,591	376,935
1914.....	11,848	2,103,316	77,483	4,555	7,250,120	12,361,082	3,520,306	324,227
1915.....	10,705	2,037,895	104,351	2,930	6,183,390	11,294,875	2,561,442	229,676
1916.....	10,650	1,992,011	51,407	2,690	4,921,151	10,711,292	2,031,497	179,674
1917.....	8,652	2,055,804	67,272	2,347	4,307,669	10,623,038	1,639,354	123,480
1918.....	22,552	2,007,828	55,396	2,477	4,025,304	10,734,224	1,578,157	111,971
1919.....	7,455	1,938,800	13,446	2,128	4,458,345	9,691,048	1,727,221	166,740
1920.....	6,766	2,193,120		2,375	5,711,184	11,408,585	2,535,411	218,735

Year.	Strontium Sulphate.	Tin.		Tungsten Ore.	Uranium Ore.	Zinc.	
		Ore, Dressed.	Block.			Ore.	Spelter.
1908.....	16,733	8,137	5,133	237	72	15,469	5,926
1909.....	14,267	8,422	5,282	382	6	10,061	5,828
1910.....	4,838	7,693	4,874	275	76	11,418	4,235
1911.....	5,963	7,870	4,950	270	68	17,935	6,196
1912.....	19,693	8,302	5,342	192	43	17,988	60,163
1913.....	18,732	8,494	5,376	185	96	18,073	5,920
1914.....	13,376	8,220	5,144	208	350	15,676	5,295
1915.....	650	8,275	5,048	334	83	12,254	4,162
1916.....	2,553	8,019	4,773	400	52	8,612	3,048
1917.....	2,618	6,682	3,998	245	13	7,604	2,779
1918.....	1,031	5,463	4,018	300	.....	9,003	3,297
1919.....	2,317	5,239	3,325	169	.....	7,045	2,475
1920.....	4,250	4,936	3,114	95	61	5,146	1,682

(*a*) From *Mineral Statistics of the United Kingdom.* (*b*) Not reported. (*c*) Bog ore, which is mined in Ireland, is an ore of iron, used principally for purifying gas. (*d*) Does not include chalk. (*e*) Includes China clay, potters' clay, and fuller's earth. (*f*) Includes production from imported ore. (*h*) Includes shale.

MINERAL IMPORTS OF THE UNITED KINGDOM (*a*)

(In metric tons or dollars; £1 = $5)

Year.	Alkali.	Asphaltum.	Borax.	Coal, Coke, and Pat. Fuel.	Copper.			Iron and Steel.		
					Ore.	Regulus and Precipitate.	Wrought, Unwrought and Old.	Iron Ore.	Pig Iron.	Scrap.
1909...	(*c*) 10,857	(*b*)	(*n*) 16,349	6,419	(*l*) 90,579	(*l*) 66,337	(*l*) 133,758	(*l*) 6,429,996	(*l*) 111,300	(*l*) 33,473
1910...	(*c*) 8,996	(*b*)	16,277	36,615	99,755	70,081	89,279	7,133,483	173,680	70,105
1911(*i*)	(*c*) 9,463	(*o*) 14,415	20,621	30,672	87,986	65,914	101,059	6,448,462	178,167	51,096
1912...	8,812	(*o*) 20,866	21,091	194,866	99,802	52,393	96,499	6,708,443	223,586	64,152
1913...	9,140	(*b*)	23,837	24,429	95,837	39,762	108,728	7,566,276	220,320	124,805
1914...	10,583	(*b*)	20,493	45,315	72,766	43,252	152,974	5,799,918	227,099	112,454
1915...	8,757	.....	21,672	3,843	38,766	39,011	183,393	6,306,547	202,500	115,125
1916...	7,789	.....	18,850	3,257	35,047	44,545	113,206	7,017,122	162,111	99,430
1917...	6,327	.....	13,740	4,382	16,821	28,696	145,077	6,289,308	157,674	28,841
1918...	95,104	.....	9,432	393	15,566	21,370	207,226	6,671,570	131,437	15,386
1919...	43,441	.....	13,740	1,115	15,774	17,616	116,864	5,286,470	166,327	113,929
1920...	.....	.....	32,167	4,588	31,666		114,289	6,605,576	217,556	442,719
1921...	.....	.....	29,481	3567495	31,348		88,257	1,919,033	693,321	190,398

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Year.	Iron and Steel (*Continued*).								Lead.	
	Puddled and Wrought	Sheets and Plates.	Rails.	Strips, Wire, and Wire Rods.	Nails, Screws, Rivets, Bolts.	Steel Ingots, Blooms, Billets, etc.	Steel Bars, Shapes, Beams, Pillars.	Mnfrs. Unenumerated.	Ore.	Pig and Sheet.
1909(*i*)	(*l*) 95,553	(*l*) 68,067	(*l*) 22,430	(*l*) 132,543	(*l*) 59,197	(*l*) 392,008	(*l*) 264,909	$2,819,365	(*b*)	(*l*) 210,982
1910..	(*l*) 98,859	88,245	16,074	163,681	58,977	361,401	349,662	3,239,715	(*b*)	222,450
1911..	119,583	115,349	36,588	173,764	62,314	512,841	500,643	(*p*) 3,654,825	(*b*)	217,134
1912..	167,774	103,224	24,640	205,749	73,745	607,470	509,002	4,270,000	(*b*)	208,671
1913 .	204,218	172,301	38,701	225,690	66,086	568,512	597,591	10,098,040	(*b*)	207,559
1914..	132,194	121,433	24,033	179,772	62,317	325,245	459,771	8,852,884	.....	227,931
1915..	46,775	31,016	15,956	199,558	65,410	453,617	108,939	8,678,975	.....	260,751
1916..	44,922	40,861	5,198	140,257	80,469	166,746	96,306	6,833,717	.....	160,529
1917..	28,776	18,807	222	83,538	51,700	59,342	66,329	5,465,405	.....	149,493
1918..	(*h*)	66,599	282	42,569	28,244	20,369	26,010	3,230,301	.....	212,296
1919..	33,400	12,630	9,884	113,137	38,389	71,883	39,629	.....	.....	221,112
1920..	92,271	177,891	14,638	165,470	53,850	262,793	49,676	.....	.....	165,472
1921..	130,376	128,547	47,308	93,528	47,078	180,896	139,342	.....	.....	134,812

Year.	Manganese Ore.	Mica, Sheet.	Mica and Talc.	Paraffin.	Petroleum. *Liters.*	Phosphate Rock.	Platinum, Wrought and Unwrought. *Kg.*	Potassium Nitrate.	Pyrites of Iron and Copper.
1909 (*i*)....	335,813	(*b*)	(*b*)	(*n*) 53,289	(*n*) 1,355,562,599	459,058	(*b*)	(*n*) 10,704	(*l*) 803,725
1910.....	489,948	(*b*)	(*b*)	(*n*) 54,073	(*n*) 1,308,396,204	462,905	(*b*)	11,558	825,284
1911.....	364,676	(*b*)	(*b*)	51,456	1,661,100,144	501,332	(*b*)	11,376	863,583
1912.....	393,798	(*b*)	(*b*)	74,836	1,879,486,588	528,620	(*b*)	11,034	921,717
1913.....	611,227	(*b*)	(*b*)	57,974	(*g*) 488,106,963	548,000	(*b*)	12,092	794,740
1914.....	487,426	.....	.....	53,576	(*g*) 646,894,523	564,865	.....	10,666	816,449
1915.....	383,613	.....	.....	93,677	(*g*) 588,469,699	380,883	.....	14,060	918,468
1916.....	446,585	.....	.....	75,217	(*g*) 451,931,774	338,738	.....	22,317	966,520
1917.....	336,597	.....	.....	73,811	(*g*) 826,895,171	281,070	.....	20,191	867,994
1918.....	371,492	.....	.....	59,171	(*g*) 1,324,495,125	472,229	.....	19,493	850,174
1919.....	270,079	.....	.....	64,120	(*g*) 723,026,780	357,481	.....	7,408	350,003
1920.....	459,900	.....	.....	69,065	(*g*) 875,199,000	531,776	.....	9,398	640,716
1921.....	175,737	.....	.....	39,886	(*g*) 1,061,456,989	376,061	.....	5,866	293,247

Year.	Quicksilver.	Silver Ore. (*d*)	Sodium Nitrate.	Sulphur.	Tin.		Zinc.		
					Ore.	Block, Ingot, Bars or Slabs.	Ore.	Spelter.	Mnfrs.
1909(*i*).....	(*m*) 1,469	$10,409,800	(*n*) 91,650	21,211	(*m*) 24,471	(*l*) 42,393	(*b*)	104,217	19,280
1910.....	1,517	9,311,565	128,528	20,496	26,490	47,028	(*b*)	123,061	18,460
1911.....	1,584	8,420,954	130,549	21,269	29,300	46,643	(*b*)	117,077	19,417
1912.....	1,607	7,523,692	125,664	22,109	29,112	43,850	(*b*)	139,461	20,673
1913.....	1,543	5,718,552	143,275	18,518	35,169	46,443	(*b*)	147,421	19,081
1914.....	1,283	4,324,576	174,775	22,162	32,938	41,644	.....	117,660	12,690
1915.....	1,381	3,446,485	134,360	36,247	45,494	39,544	.....	75,762	8,170
1916.....	1,159	3,429,646	21,232	37,281	34,458	34,188	.....	54,183	3,729
1917.....	985	4,317,690	1,707	29,835	41,871	27,580	.....	77,330	4,171
1918.....	489	3,079,161	305	73,891	32,850	12,769	.....	68,242	.....
1919.....	1,289	3,797,075	24,879	7,695	36,312	23,271	.....	95,643	4,757
1920.....	1,281	£920,094	149,850	16,013	34,354	29,212	.....	111,128	7,663
1921.....	744	£644,443	56,760	9,798	21,947	21,316	.....	73,694	11,215

(*a*) From *Accounts Relating to trade and Navigation of the United Kingdom.* (*b*) Not reported. (*c*) Classified as soda compounds since 1901. (*d*) Includes the value of silver in argentiferous ore and metal. (*f*) Not separately enumerated. (*g*) Gallons. (*h*) Included in pig iron. (*i*) From *Mines and Quarries.* (*l*) From *Iron and Coal Trades Review.* (*m*) *Min. Jour.* (*n*) *Oil, Paint and Drug Reporter.* (*o*) From Trinidad. (*p*) There are besides, not here given, pipes, castings and forgings amounting to 51,000 tons.

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MINERAL EXPORTS OF THE UNITED KINGDOM—DOMESTIC PRODUCTS (a)

(In metric tons or dollars; £1 = $5)

Year.	Bleaching Materials.	Cement.	Coal.	Coke.	Patent Fuel.	Supplied to Steamers.	Coal Products. (c)
1909	(n) 46,321	607,825	64,089,132	(l) 1,180,218	(l) 1,479,142	20,029,427	(n) 7,276,050
1910(k)	(n) 51,188	747,627	(l) 63,081,948	979,526	1,494,397	(l) 19,839,123	(n) 8,398,405
1911	46,416	727,092	65,636,084	1,076,887	1,638,625	19,573,379	£2,517,355
1912	41,989	656,460	65,479,346	1,042,489	1,590,557	18,584,946	£2,981,159
1913	36,928	761,232	74,623,453	1,254,502	2,087,407	21,382,032	£2,279,790
1914	30,458	608,344	60,023,878	1,202,562	1,634,553	18,844,505	£2,283,062
1915	25,086	432,243	44,260,350	1,027,140	1,245,489	13,858,147	£2,554,008
1916	8,794	416,602	38,969,013	1,505,350	1,346,023	13,197,282	£3,212,046
1917	2,650	363,441	35,559,219	1,299,232	1,550,843	10,392,422	£3,130,976
1918	3,074	202,522	32,264,126	930,667	1,529,321	8,897,455	£2,883,096
1919	17,725	392,069	35,817,086	1,532,289	1,735,514	12,214,784	£3,411,806
1920	22,044	630,400	25,333,256	1,699,865	2,294,267	14,063,190	£5,591,507
1921	8,075	300,150	25,071,561	748,483	864,232	11,108,551	£2,687,714

Year.	Copper.				Iron.				
	Ingot.	Mixed or Yellow Metal.	Mfrs.	Sulphate.	Ore.	Pig.	Scrap.	Cast Iron and Mfrs.	Wrought Iron, Shapes and Mfrs.
1909(k)	12,465	(m) 11,381	17,248	(m) 45,547	(l) 5,185	(l) 1,026,517	(l) 165,183	(l) 44,406	(l) 171,697
1910	11,898	(m) 15,970	12,551	43,391	(l) 7,464	(l) 1,062,444	(l) 150,507	(l) 57,148	(q) 143,702
1911	10,970	15,101	24,669	81,112	(l) 6,352	1,222,622	147,759	(l) 70,618	140,318
1912	12,993	11,108	19,327	85,497	6,241	1,284,220	127,610	68,676	144,747
1913	15,165	14,711	22,317	76,950	5,278	1,142,917	117,645	82,816	139,593
1914	7,390	13,420	18,367	69,015	13,742	793,703	90,037	73,339	151,062
1915	6,764	3,923	14,076	66,297	1,697	621,810	52,031	47,647	121,826
1916	9,339	1,654	8,114	39,437	1,263	932,166	62,596	36,895	140,158
1917	5,262	497	3,611	47,888	678	745,590	17,026	23,288	10,897
1918	4,099	7,644	2,526	48,373	163	489,924	11,070	15,093	7,210
1919	10,694	227	15,499	35,653	2,507	362,384	29,732	23,430	15,241
1920	14,960	49,993	26,045	20,172	2,357	588,784	46,083	26,963	59,924
1921	11,066	20,563	18,990	28,471	1,496	138,264	39,846	17,775	31,965

Year.	Iron (*Continued*).								
	Rails.	Wire and Mfrs. of.	Plates and Sheets.	Galvanised Sheets.	Black Plates for Tinning.	Tinned Plates.	Steel Ingots, Billets, Blooms, etc.	Steel Shapes, Beams, and Pillars.	Total Iron and Steel, and Mfrs. of.
1909(k)	(l) 589,499	(l) 107,406	(l) 169,918	(l) 502,791	(l) 61,025	(l) 446,781	(l) 3,217	(l) 309,555	4,278,172
1910	490,068	(l) 124,703	(l) 197,858	(l) 606,530	(l) 56,691	(l) 490,733	(l) 3,340	(q) 230,850	4,661,647
1911	381,320	(l) 129,252	(l) 203,850	627,215	(l) 68,137	492,104	(l) 4,376	231,793	4,588,385
1912	418,742	121,215	218,585	669,252	66,775	488,629	4,241	245,033	4,891,270
1913	517,251	118,814	204,452	774,948	72,977	503,170	4,942	255,580	5,017,456
1914	451,030	100,938	145,017	576,044	58,192	442,755	5,784	328,061	3,946,688
1915	257,552	64,407	250,400	291,187	54,383	374,742	16,106	555,115	3,248,454
1916	55,263	53,281	340,741	119,097	139,138	326,890	84,186	642,469	3,349,294
1917	39,813	49,791	259,474	19,225	13,685	180,071	435,650	74,627	2,366,330
1918	27,354	19,010	231,597	8,977	4,647	227,062	162,109	65,303	1,633,993
1919	127,832	59,690	377,850	189,097	33,034	294,426	253,429	59,188	2,260,806
1920	136,722	121,226	342,391	417,548	36,896	359,419	371,391	99,664	3,305,602
1921	185,915	35,762	179,681	215,155	14,380	230,257	110,969	40,015	1,728,747

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Year.	Lead, Pig and Mfrs	Salt.	Sodium.				Tin, Block.	Zinc.		
			Soda Ash.	Carbonate and Bicarbonate.	Hydrate.	Sulphate.		Ore.	Spelter.	Mfrs.
1909(*k*)	(*m*) 46,399	523,690	(*n*) 97,480	(*n*) 23,378	(*n*) 80,439	(*n*) 35,587	11,373	(*b*)	(*m*) 8,684	(*i*)
1910 ..	47,588	571,845	110,188	23,295	84,291	58,960	12,576	(*b*)	9,247	(*i*)
1911 ..	44,733	614,572	125,945	26,353	82,356	59,382	11,736	(*b*)	9,736	(*i*)
1912 ..	47,782	557,291	144,073	29,403	79,527	50,759	12,152	(*b*)	10,881	.....
1913 ..	49,261	542,157	159,714	39,175	76,152	67,504	11,687	....	11,313	.....
1914 ..	36,486	504,848	181,754	37,724	75,618	40,366	13,599	.....	7,580	.....
1915 ..	40,835	508,022	221,850	43,517	56,781	31,931	14,389	.....	2,428	.....
1916 ..	28,883	396,518	159770	45,268	29,670	24,760	18,315	.....	3,621	.....
1917 ..	9,466	313,603	162,852	29,961	25,383	21,070	19,597	.....	7,939	.....
1918 ..	4,997	259,382	171,526	23,005	22,295	30,047	15,483	.....	1,407	.....
1919 ..	25,982	350,768	171,559	36,634	26,660	26,581	14,859	.....	6,612	.....
1920 ..	35,185	390,325	227,891		48,347	103,524	13,550	.....	10,474	.....
1921 ..	16,496	243,788	152,848		29,919	20,975	10,065	.....	7,548	.....

(*a*) From *Accounts Relating to Trade and Navigation of the United Kingdom.* (*b*) Not reported. (*c*) Including naphtha, paraffin, paraffin oil and petroleum. (*d*) Previous reports not available. (*e*) Includes puddled iron. (*f*) Includes railroad material of all kinds. (*g*) Includes all soda compounds; not separate; enumerated previous to 1901. (*h*) Included under soda ash. (*i*) Included under spelter. (*k*) From *Mines and Quarries.* (*l*) From *Iron and Coal Trades Review.* (*m*) *Mining Journal.* (*n*) From *Oil, Paint and Drug Reporter.* (*q*) Bars only.

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UNITED STATES

Of the following tables, the first records the imports of foreign mineral and metal products into the United States, whether dutiable or duty-free; the second shows the exports of materials produced in the United States; and the third reports the re-exports of products of foreign origin. These statistics are as reported by the Bureau of Foreign and Domestic Commerce, Department of Commerce, and special acknowledgment is due to the Chief of this Bureau, for furnishing the figures for many substances which are not reported in the Monthly Summary. The complete statement of production in the United States is given under the separate chapters.

IMPORTS (*a*)

Year.	Aluminium. Crude. Lb.	Kg.	Value.	Value per Lb.	Ammonium Sulphate. Lb.	Metric Tons.	Value.	Value per Lb.
1912	22,759,937	10,326,650	$3,092,889	$0.136	119,085,120	54,049	$3,447,225	$0.029
1913	23,185,775	10,519,861	3,905,977	0.169	130,549,440	59,252	3,957,307	0.030
1914	16,241,340	7,369,029	2,729,383	0.168	166,031,040	75,356	4,475,603	0.027
1915	8,534,834	3,871,375	1,511,988	0.165	72,748,480	33,008	1,934,625	0.027
1916	6,646,385	3,014,734	1,729,298	0.260	29,034,880	13,171	954,815	0.033
1917	58,703	26,627	18,084	0.308	16,269,120	7,380	649,125	0.041
1918	1,800,436	816,660	569,150	0.316	6,704,320	3,041	425,881	0.063
1919	17,644,004	8,003,144	5,810,557	0.329	5,272,960	2,407	313,873	0.059
1920	40,074,132	18,177,225	11,880,176	0.297	4,466,560	2,026	247,495	0.055
1921	30,577,790	13,869,780	6,707,892	0.219	10,476,480	4,752	260,390	0.025

Year.	Antimony. (*p*) Lb.	Metric Tons.	Value.	Value per Lb.	Antimony Ore. (*r*) Lb.	Metric Tons.	Value.	Value per Lb.
1912	17,645,870	8,006	$936,920	$ 0.053	*Nil.*	.....	.....	.....
1913	15,333,492	6,957	878,773	0.057	49,803	221	$1,739	$0.035
1914	13,070,381	5,930	737,233	0.056	1,986,082	901	54,408	0.027
1915	17,484,030	7,933	3,633,420	0.206	3,374,012	1,531	351,540	0.104
1916	19,749,830	8,958	5,219,885	0.264	9,485,423	4,303	1,049,806	0.111
1917	35,649,113	16,171	4,297,680	0.121	11,920,443	5,406	1,031,998	0.087
1918	27,748,318	12,586	2,664,263	0.096	2,719,062	1,233	176,138	0.065
1919	14,250,158	6,464	870,767	0.061	727,462	330	49,527	0.068
1920	24,947,121	11,316	1,475,276	0.059	1,363,441	618	70,285	0.052
1921	21,153,331	9,595	697,121	0.033	196,107	89	11,682	0.060

Year.	Asbestos. Crude, Value.	Mfd., Value.	Total Value.	Asphaltum. Long Tons.	Metric Tons.	Value.	Value per L. T.
1912	$1,456,012	$363,759	$1,819,771	194,775	198,021	$919,467	$4.72
1913	1,928,705	389,664	2,318,369	193,783	197,012	911,921	4.71
1914	1,407,758	368,344	1,776,102	124,214	126,284	682,748	5.50
1915	1,981,483	137,320	2,118,803	123,436	125,452	680,357	5.51
1916	3,303,470	135,064	3,438,534	131,611	134,035	735,102	5.57
1917	4,521,172	65,096	4,586,268	167,809	170,510	993,668	5.92
1918	6,337,585	27,476	6,365,061	102,428	104,077	627,495	6.13
1919	7,369,685	257,381	7,627,066	94,329	95,860	615,499	6.52
1920	9,120,253	619,054	9,739,307	114,655	116,501	1,067,616	9.32
1921	2,948,302	379,858	3,328,160	114,763	116,611	1,129,290	9.68

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Year.	Arsenic. (b)				Barytes.				Bauxite.			
	Lb.	Metric Tons.	Value.	Value per Lb.	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1912....	12,964,946	5,881	$447,431	$0.035	26,665	27,093	$79,315	$2.97	26,214	26,635	$95,431	$3.64
1813....	9,726,216	4,412	419,134	0.043	36,875	37,490	99,564	2.97	21,456	21,814	85,746	3.99
1914....	7,267,372	3,297	274,387	0.038	25,598	26,025	77,265	3.02	24,844	25,258	96,500	3.88
1915....	6,373,024	2,891	268,194	0.042	3,404	3,460	15,613	4.59	3,421	3,477	17,500	5.12
1916....	4,322,321	1,961	232,720	0.054	146	148	2,317	15.87	30	30	87	2.90
1917....	7,909,045	3,584	674,875	0.085	84	85	1,806	21.50	7,691	7,815	28,989	3.77
1918....	14,996,140	6,802	1,439,223	0.069	*Nil.*	*Nil.*	*Nil.*	.....	3,653	3,712	14,791	4.05
1919....	13,080,573	5,933	941,181	0.072	105	107	594	5.66	6,082	6,180	36,820	5.99
1920....	15,640,000	7,094	1,216,651	0.078	22,209	22,566	146,858	6.61	42,895	43,586	251,284	5.86
1921....	10,024,595	4,547	784,572	0.078	10,765	10,938	76,313	7.09	27,587	28,031	164,589	5.97

Year.	Bismuth.				Chrome Ore.				Coal, Anthracite.			
	Lb.	Kg.	Value.	Value per Lb.	Long Tons.	Metric Tons.	Value.	Value per L.T.	Long Tons.	Metric Tons.	Value.	Value per L.T.
1912 .	182,839	82,935	$316,440	$ 1.73	53,929	54,828	$499,818	$9.27	1,670	1,698	$8,329	$4.99
1913 .	117,747	53,424	213,257	1.81	65,180	66,266	627,821	9.56	921	936	5,697	6.19
1914 .	90,505	41,064	165,248	1.83	74,686	75,931	655,306	8.77	19,347	19,669	37,998	1.96
1915 .	44,362	20,122	108,288	2.44	76,455	77,704	780,061	10.20	2,998	3,047	14,922	4.98
1916 .	76,723	34,801	195,975	2.55	115,886	117,752	1,548,402	13.36	5,693	5,785	19,316	3.39
1917 .	69,250	31,411	142,300	2.05	72,063	73,223	1,098,650	15.25	11,188	11,368	46,523	4.16
1918 .	135,700	61,552	277,273	2.04	100,142	101,754	2,891,725	28.88	33,279	33,815	204,385	6.15
1919 .	57,607	26,130	55,179	0.96	61,404	62,393	1,381,497	22.49	73,945	75,135	522,419	7.06
1920 .	72,771	33,008	161,877	2.22	150,275	152,694	1,921,824	12.79	28,346	28,802	257,835	9.09
1921 .	94,085	42,676	114,891	1.22	81,836	82,154	654,602	8.00	7,950	8,078	93,236	11.73

Year.	Coal, Bituminous.				Total Coal.		Coke.			
	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Value.	Long Tons.	Metric Tons.	Value.	Value per L. T
1912....	1,608,350	1,635,156	$4,509,636	$2.80	1,610,020	$4,517,965	110,347	112,186	$488,691	$4.43
1913....	1,413,857	1,437,421	3,856,811	2.73	1,414,778	3,862,508	93,507	95,065	442,687	4.73
1914....	1,375,316	1,398,238	3,889,821	2.80	1,394,663	3,927,819	120,777	122,790	555,548	4.60
1915....	1,521,237	1,546,085	4,398,425	2.96	1,524,235	4,413,347	47,520	48,296	222,382	4.68
1916....	1,530,212	1,554,848	4,714,433	3.08	1,535,905	4,733,749	49,067	49,857	249,514	5.09
1917....	1,293,262	1,314,084	4,795,110	3.71	1,304,450	4,841,633	22,207	22,565	146,451	6.60
1918....	1,301,229	1,322,178	6,694,081	5.14	1,334,508	6,898,466	26,936	27,370	221,880	8.23
1919....	903,170	917,711	4,950,686	5.48	977,115	5,473,105	14,720	14,500	140,653	9.86
1920....	1,111,598	1,129,495	6,733,676	6.05	1,139,944	6,991,511	36,735	37,326	403,175	10.97
1921....	1,122,847	1,140,925	7,363,945	6.56	1,130,797	7,457,181	27,670	28,109	336,394	12.16

Year.	Chloride of Lime.				Cement.			
	Lb.	Metric Tons.	Value.	Value per Lb.	Barrels. (c)	Metric Tons.	Value.	Value per Bbl.
1912.....	74,235,256	33,682	$597,002	$0.008	65,064	11,808	$93,583	$1.44
1913.....	61,605,077	27,951	510,120	0.0083	77,333	14,035	134,187	1.74
1914.....	34,539,934	15,671	332,792	0.0096	115,770	20,920	193,155	1.68
1915.....	7,564,473	3,432	102,570	0.0135	40,097	7,275	57,149	1.43
1916.....	1,605,036	728	52,628	0.0328	1,714	311	4,924	2.87
1917.....	4,000	2	140	0.0350	2,207	400	6,075	2.75
1918.....	539,881	245	11,407	0.0211	287	52	1,185	4.13
1919.....	417,412	189	8,936	0.0214	8,081	1,466	51,363	6.36
1920.....	2,474,617	1,122	86,873	0.0351	473,134	85,848	1,229,431	2.60
1921.....	12,438,484	5,642	229,113	0.0184	114,978	20,861	388,828	3.38

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Year.	Cobalt Oxide.				Copper, Ore and Matte.			
	Lb.	Kg.	Value.	Value per Lb.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1912.....	31,848	14,446	$15,132	$0.475	499,549	507,875	$12,696,532	$25.42
1913.....	47,277	21,451	26,154	0.553	511,163	519,682	13,573,327	26.55
1914.....	227,886	103,397	220,593	0.97	417,222	424,176	12,172,138	29.17
1915.....	154,672	70,159	148,828	0.96	414,423	421,147	13,929,883	33.61
1916.....	206,639	93,756	192,009	0.93	631,168	641,330	29,799,581	47.21
1917.....	276,406	125,378	275,821	1.00	593,143	602,693	34,650,864	58.42
1918.....	208,596	94,617	291,699	1.40	493,675	501,623	34,334,820	69.55
1919.....	131,424	59,613	184,751	1.40	416,549	423,255	23,541,020	56.60
1920.....	202,704	91,944	399,605	1.97	414,636	421,312	21,890,449	52.79
1921.....	164,003	74,390	342,426	2.09	379,428	385,537	14,229,486	37.50

Year.	Copper, Ingots, Old, etc.				Cryolite.			
	Lb.	Metric. Tons.	Value.	Value. per Lb.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1912.....	305,369,592	138,552	$44,259,727	$0.145	2,126	2,160	$48,293	$22.72
1913.....	300,068,849	136,147	44,328,574	0.148	2,559	2,602	52,557	20.54
1914.....	201,549,503	91,447	27,813,866	0.138	4,613	4,690	94,424	20.47
1915.....	201,367,008	91,360	30,617,535	0.152	3,940	4,004	82,750	21.00
1916.....	287,548,126	130,429	65,384,132	0.227	3,857	3,919	165,222	42.84
1917.....	380,669,290	172,672	102,877,783	0.270	4,383	4,453	218,500	49.85
1918.....	418,588,634	189,868	99,103,163	0.235	1,950	1,981	97,500	50.00
1919.....	302,932,531	137,407	62,603,993	0.207	2,131	2,166	106,956	50.19
1920.....	369,233,636	167,481	67,822,990	0.184	3,864	3,926	193,638	50.11
1921.....	247,672,691	112,342	31,405,967	0.127	3,460	3,516	295,186	85.31

Year.	Emery Grains.				Emery Rock.			
	Lb.	Metric. Tons.	Value.	Value per Lb.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1912....	791,667	359	$32,876	$0.042	15,793	16,052	$284,585	$18.01
1913....	2,496,372	1,133	114,806	0.046	17,122	17,377	342,809	20.03
1914....	761,674	346	30,017	0.039	12,662	12,873	255,554	20.10
1915....	569,639	258	22,655	0.040	8,313	8,449	180,594	21.72
1916....	217,725	99	9,286	0.043	7,511	7,632	102,459	13.64
1917....	240,764	109	14,654	0.061	650	660	8,875	13.65
1918....	623,241	284	32,499	0.052	4,956	5,036	148,228	29.91
1919....	392,789	178	22,432	0.057	8,302	8,436	235,596	28.42
1920....	543,514	247	22,462	0.041	5,398	5,485	222,321	41.19
1921....	187,851	85	7,973	0.042	5,181	5,264	179,957	34.73

Year.	Fuller's Earth.		Gold.		Iron Ore.			
	Long Tons.	Value.	In Coin and Bullion.	In Ore.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1912...	17,062	$145,337	$55,789,906	$10,758,866	2,104,576	2,139,652	$6,499,690	$3.09
1913...	16,632	146,001	51,618,628	12,086,204	2,594,770	2,638,016	8,336,819	3.21
1914...	22,302	195,083	46,311,059	11,076,682	1,350,588	1,373,891	4,483,832	3.32
1915...	17,349	152,493	438,302,822	13,651,768	1,341,281	1,363,189	4,181,645	3.12
1916...	15,001	139,664	672,588,232	13,402,002	1,326,864	1,348,226	4,570,875	3.44
1917...	15,174	176,417	536,945,793	15,508,581	971,663	987,307	3,655,392	3.76
1918...	11,256	165,535	45,790,718	15,868,386	787,468	800,146	3,464,304	4.40
1919...	12,387	189,711	59,789,616	16,844,430	476,461	484,132	2,385,689	5.01
1920...	17,174	221,893	414,255,260	17,018,724	1,273,456	1,293,959	4,963,654	3.90
1921...	8,700	119,415	691,270,945	35,465,726	315,768	320,852	1,075,909	3.41

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Year.	Phosphates, Crude.				Pig Iron.			
	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1912....	28,821	29,284	$231,255	$8.02	129,325	131,481	$4,770,730	$36.89
1913....	26,408	26,833	206,719	7.83	156,450	159,058	6,557,095	41.91
1914....	15,178	15,431	136,526	9.00	139,683	141,218	4,694,186	33.60
1915....	5,359	5,446	50,606	9.44	89,836	91,303	4,108,180	45.73
1916....	4,612	4,686	36,389	7.89	135,349	137,528	10,239,868	75.65
1917....	92	93	1,169	12.71	76,786	78,022	7,872,105	102.51
1918....	*Nil.*	*Nil.*	*Nil.*	.....	34,711	35,270	4,968,056	143.12
1919....	34	35	457	13.44	101,665	103,302	6,565,106	64.57
1920....	63	64	2,090	33.19	185,944	188,938	12,801,834	68.84
1921....	3,535	3,592	43,960	12.43	44,516	45,233	2,014,926	45.26

Year.	Iron and Steel Scrap.			Bar Iron.		
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1912.....	23,612	24,006	$256,710	26,112	26,547	$1,151,853
1913.....	44,154	44,890	510,707	28,243	28,714	1,340,184
1914.....	34,849	35,430	277,818	15,015	16,688	625,365
1915.....	79,982	81,243	761,719	8,474	8,659	417,491
1916.....	116,039	117,907	1,140,704	7,701	7,825	647,393
1917.....	180,034	182,932	2,437,423	2,240	2,276	193,831
1918.....	70,419	64,757	1,341,343	1,469	1,493	194,597
1919.....	182,549	180,147	3,341,150	1,940	1,971	220,868
1920.....	140,645	142,909	2,915,589	4,987	5,067	677,182
1921.....	41,469	42,137	479,800	1,913	1,944	203,486

Year.	Rails.			Hoop, Band or Scroll.			Ingots, Blooms, Slabs, Billets, etc.		
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1912...	3,780	3,843	$101,544	(§)	(§)	(§)	18,702	19,014	$2,941,481
1913...	10,408	10,581	216,272	(§)	(§)	(§)	26,765	27,202	3,505,463
1914...	22,571	22,947	610,037	648	659	$23,702	40,189	40,845	2,943,047
1915...	78,525	79,808	2,088,532	*Nil*	*Nil*	*Nil*	14,998	15,243	1,941,601
1916...	26,299	26,722	740,109	*Nil*	*Nil*	*Nil*	26,142	26,561	3,239,642
1917...	9,263	9,412	307,139	*Nil*	*Nil*	*Nil*	44,198	44,910	3,948,936
1918...	8,705	8,846	341,985	*Nil*	*Nil*	*Nil*	41,070	41,735	3,700,157
1919...	17,008	17,282	651,830	*Nil*	*Nil*	*Nil*	16,266	16,528	3,848,745
1920...	45,684	46,420	1,922,409	*Nil*	*Nil*	*Nil*	24,232	24,622	4,892,600
1921...	22,048	22,403	847,122	*Nil*	*Nil*	*Nil*	10,024	10,191	1,290,394

Year.	Sheet, Plate and Taggers, Iron or Steel.			Tin Plates, Terne Plates and Taggers Tin.			Wire Rods.		
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1912...	3,299	3,354	$363,141	2,053	2,087	$229,891	15,069	15,320	$726,205
1913...	2,893	2,941	381,593	20,680	21,025	1,478,635	16,098	16,366	802,401
1914...	4,310	4,382	514,080	15,411	15,668	1,049,297	6,954	7,070	373,615
1915...	1,416	1,444	218,954	2,350	2,389	196,328	5,317	5,403	331,724
1916...	1,730	1,758	345,622	1,008	1,024	214,574	4,130	4,196	509,559
1917...	1,748	1,775	526,788	124	126	31,453	1,060	1,077	221,184
1918...	1,517	1,541	632,558	32	32	5,964	7,677	7,800	621,936
1919...	1,096	1,114	455,559	242	246	66,944	342	348	63,572
1920...	1,791	1,820	589,199	400	407	130,143	5,488	5,576	746,953
1921...	1,976	2,008	301,423	455	462	122,880	912	927	115,942

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Year.	Wire and Articles Made from.			Total Iron Imports. (e)	Lead in Ore and Base Bullion.		
	Long Tons.	Metric Tons.	Value.		Short Tons.	Metric Tons	Value.
1912 ...	§	§	$1,103,192	$29,328,709	83,283	75,576	$3,721,583
1913 ...	§	§	1,167,368	33,601,985	57,105	51,817	2,962,139
1914 ...	§	§	1,205,456	28,642,862	28,190	25,580	1,867,064
1915 ...	§	§	640,521	20,380,093	51,086	46,358	3,431,829
1916 ...	§	§	652,889	28,131,095	29,674	26,921	2,933,022
1917 ...	§	§	348,786	25,882,335	72,478	65,752	8,879,980
1918 ...	§	§	273,705	24,947,077	93,367	84,701	10,208,766
1919 ...	§	§	463,054	26,880,164	65,799	59,793	5,453,537
1920 ...	§	§	1,440,813	50,305,603	62,796	56,969	7,216,128
1921 ...	§	§	1,259,811	28,751,729	42,984	38,995	2,553,000

Year.	Lead in Pigs and Old.			Lead, Sheet, Pipe, Shot, etc.			Other Lead Mfrs.	Total Lead.
	Short Tons.	Metric Tons.	Value.	Lb.	Metric Tons.	Value.		
1912.....	272	247	$19,917	31,284	14	$2,305	$7,328	$3,748,828
1913.....	41	37	3,678	§	§	§	17,138	2,982,955
1914.....	148	134	10,082	§	§	§	83,672	1,960,818
1915.....	410	372	28,154	201,510	91	17,059	131,635	3,591,618
1916.....	5,655	5,773	761,537	532	.....	63	106,119	3,800,678
1917.....	5,793	5,255	649,205	12,538	6	2,699	12,966	9,542,151
1918.....	5,240	4,754	645,281	6,892	3	624	37,391	10,891,438
1919.....	5,107	4,633	417,126	8,018	4	628	17,447	5,888,370
1920.....	35,719	32,404	4,019,684	81,396	37	5,483	27,447	11,263,370
1921.....	31,301	28,396	1,992,613	3,087	1	140	11,088	4,556,841

Year.	White Lead.				Litharge.				Red Lead.			
	Lb.	Metric Tons.	Value.	Value per lb.	Lb.	Metric Tons.	Value.	Value per lb.	Lb.	Metric Tons	Value.	Value per lb.
1912...	687,705	312	$46,494	$0.068	32,443	15	$1,550	$0.048	757,908	344	$33,854	$0.045
1913...	671,839	305	48,266	0.072	34,023	15	1,750	0.051	99,562	45	4,903	0.049
1914...	707,774	321	50,989	0.072	33,651	15	1,805	0.054	6,014	3	260	0.044
1915..	339,157	154	24,608	0.073	20,650	9	1,422	0.069	1,968	1	132	0.067
1916...	88,617	40	8,050	0.091	1,320	1	150	0.114	20,467	9	5,302	0.259
1917...	20,238	9	1,965	0.097	*Nil.*	.....	.....	.....	50	.....	13	0.260
1918...	158	.....	131	.....	100	.....	12	0.120	5	.....	1	0.200
1919...	21,213	9	2,490	0.117	*Nil.*	.....	.....	.....	7,199	3	1,136	0.158
1920...	159,977	73	19,449	0.121	21,002	10	2,647	0.126	23,056	11	1,789	0.078
1921...	124,176	56	12,598	0.101	100	.....	7	0.070	12,236	6	689	0.056

Year.	Orange Mineral.				Magnesite.			
	Lb.	Metric Tons.	Value.	Value per Lb.	Long Tons.	Metric Tons.	Value.	Value per L.T.
1912.....	334,551	152	$20,914	$0.063	123,801	125,788	$1,369,665	$11.06
1913.....	330,525	150	22,205	0.067	161,012	163,606	1,757,476	10.92
1914.....	240,388	109	16,288	0.068	120,688	122,609	1,427,773	11.86
1915.....	171,572	78	14,061	0.082	68,159	69,272	647,241	9.41
1916.....	70,934	32	8,781	0.124	75,549	76,765	838,630	11.10
1917.....	33,294	15	4,892	0.147	30,574	31,066	464,706	15.20
1918.....	*Nil.*	.....	.....	.....	21,858	22,209	927,255	42.43
1919.....	39,781	18	5,082	0.128	14,153	14,381	374,032	27.01
1920.....	52,094	24	5,352	0.103	43,154	43,849	780,078	18.06
1921.....	77,937	35	7,830	0.100	52,483	53,328	776,384	14.80

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Year.	Manganese Ore.				Mica. (d)	Nickel. (h)	Nickel Ore and Matte.		
	Long Tons.	Metric Tons.	Value.	Value per L. T.			Long Tons.	Metric Tons.	Value.
1912.....	300,661	305,672	$1,769,184	$5.84	$745,399	$120,511	33,101	33,653	$5,638,456
1913.....	345,090	350,842	2,029,680	5.87	981,601	(f)	37,623	38,250	6,427,639
1914.....	283,294	288,016	2,024,120	5.88	204,850	(f)	29,564	30,056	4,956,448
1915.....	313,985	319,040	2,633,286	8.40	244,292	19,929	45,798	46,546	7,615,999
1916.....	576,321	585,600	8,666,179	15.04	1,126,271	36,098	59,741	60,703	9,889,122
1917.....	629,972	640,118	10,262,929	15.92	1,368,020	50,011	61,053	62,036	9,612,400
1918.....	491,303	499,213	15,095,867	30.73	1,545,105	118,472	59,621	60,581	11,517,546
1919.....	333,344	338,711	11,229,184	33.68	1,632,834	2,643,882	23,057	23,428	5,780,380
1920.....	606,937	616,709	12,230,922	20.15	3,474,553	2,396,010	32,650	33,176	8,463,872
1921.....	401,354	407,816	3,365,732	8.39	1,180,119	884,006	1,507	1,531	432,786

Year.	Oil, Mineral.			Platinum, Unmanufactured.				Platinum Mfrs.
	Gal.	Value.	Value per Gal.	Lb. Troy.	Kg.	Value.	Value per Lb. Troy.	
1912....	309,765,930	$6,033,231	$0.019	3,692	1,378	$1,716,630	$464.96	$2,777,853
1913....	731,360,523	12,997,011	0.018	4,283	1,599	1,978,770	462.01	3,065,489
1914 ...	724,446,909	11,500,730	0.016	2,676	999	1,154,955	431.60	1,818,668
1915....	763,705,698	10,563,628	0.014	4,644	1,733	2,077,536	447.35	334,472
1916....	890,353,850	13,887,263	0.016	3,436	1,283	2,506,531	729.49	650,788
1917....	1,324,157,815	20,604,606	0.016	2,179	813	2,095,390	961.45	319,765
1918....	1,635,597,145	25,669,795	0.016	3,819	1,426	4,144,740	1,085.29	819,240
1919....	2,274,771,088	31,440,627	0.014	3,996	1,491	4,556,353	1,140.23	690,169
1920....	4,569,341,177	65,902,780	0.014	4,818	1,798	6,050,868	1,255.87	2,518,039
1921....	5,408,888,244	77,389,637	0.014	3,723	1,390	2,851,489	765.91	1,292,270

Year.	Potassium Salts.											
	Chlorate.			Chloride.			Chromate and Bichromate.			Nitrate.		
	Lb.	Value.	Value per Lb.	Lb.	Value.	Value per Lb.	Lb.	Value.	Value per Lb.	Lb.	Value.	Value per Lb.
		$	$		$	$		$	$		$	$
1912....	99,919	6,787	0.068	482,265,665	7,229,109	0.015	32,913	3,085	0.094	7,315,531	216,492	0.030
1913....	1,191,461	64,468	0.054	478,826,857	7,120,055	0.015	18,629	1,819	0.097	9,876,910	262,575	0.027
1914....	27,406	2,235	0.083	371,520,195	5,745,385	0.015	31,858	2,375	0.075	2,229,856	74,743	0.034
1915....	16,001	3,666	0.229	129,346,560	2,297,149	0.018	32,942	2,902	0.088	127,270	28,095	0.022
1916....	10,199	7,189	0.705	2,598,400	348,961	0.134	459	75	0.163	11,537,033	1,519,375	0.131
1917....	1,006,740	404,783	0.402	1,366,400	158,410	0.116	2,404	962	0.400	9,217,004	667,209	0.072
1918....	709,805	248,160	0.350	848,960	102,109	0.120	20	8	0.400	9,349,305	907,279	0.097
1919....	199,077	34,996	0.176	46,403,840	1,783,916	0.038	15,450	4,271	0.277	37,652,334	1,107,313	0.029
1920....	1,484,000	162,417	0.109	272,388,480	12,703,858	0.047	4,414	2,690	0.609	37,632,131	1,599,346	0.042
1921....	5,542,000	246,191	0.044	159,284,160	4,777,726	0.030	73,011	6,772	0.093	16,593,849	590,200	0.036

Year	Potassium Salts, All Other. (s)		Precious Stones. (t)			Pyrite. (i)			
	Lb.	Value.	Uncut.	Cut, not Set.	Jewelry.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1912.	131,049,932	$3,185,098	$9,979,582	$26,218,261	$989,288	964,478	980,553	$3,860,738	$3.88
1913.	124,519,551	3,253,245	12,630,037	27,626,937	998,723	848,674	862,819	3,611,136	4.00
1914.	.....	.....	3,008,823	13,652,861	775,364	977,372	993,662	4,706,383	4.82
1915.	41,109,008	1,461,637	7,124,316	14,161,769	387,150	974,616	990,531	4,817,977	4.95
1916.	6,578,291	449,538	11,522,198	26,420,425	307,510	1,244,519	1,264,556	6,728,318	5.41
1917.	9,373,123	1,780,883	13,573,806	20,168,954	252,730	967,340	982,914	5,981,457	6.16
1918.	9,752,991	2,717,386	13,210,076	8,729,904	185,939	498,786	506,816	2,767,448	5.55
1919.	5,429,582	675,642	21,939,280	69,228,979	726,574	388,973	395,235	2,176,565	5.59
1920.	82,593,796	5,519,672	14,245,103	50,476,638	1,361,572	332,606	337,960	1,660,832	5.00
1921.	47,960,306	2,041,256	2,991,218	28,925,859	1,242,630	216,229	219,710	818,852	3.79

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Year.	Salt.				Silver.		Sodium Nitrate.			
	Short Tons.	Metric Tons.	Value.	Value per Sh. T.	In Coin and Bullion.	In Ore.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1912..	136,391	123,762	$361,664	$2.65	$24,053,983	$24,347,103	486,352	494,458	$16,554,104	$34.04
1913..	150,602	136,609	416,375	2.77	19,979,971	15,887,848	625,862	636,293	21,630,811	34.56
1914..	130,752	118,649	385,752	2.95	18,941,980	7,017,207	541,715	552,777	15,228,671	28.01
1915..	123,576	112,138	366,475	2.97	26,375,801	8,108,163	772,190	784,803	22,959,997	29.73
1916..	121,967	110,648	342,588	2.81	13,615,185	18,648,104	1,218,423	1,238,041	38,131,962	31.29
1917..	65,840	59,730	280,135	4.25	15,671,915	37,668,562	1,543,213	1,568,059	60,437,526	39.16
1918..	40,315	36,574	284,032	7.05	28,148,065	44,773,517	1,845,074	1,874,900	90,360,207	48.98
1919..	62,821	56,991	324,402	5.16	15,336,686	74,073,332	407,459	414,019	19,558,963	48.00
1920..	137,654	124,880	676,499	4.92	18,213,514	69,857,844	1,321,892	1,343,205	63,121,035	47.76
1921..	93,095	84,456	531,031	5.70	16,681,452	46,640,993	369,173	375,117	17,982,977	48.71

Year.	Sodium Hydroxide (Caustic).			Soda Ash and Carbonate.			All other Sodium Salts.	
	Lb.	Value.	Value. per Lb.	Lb.	Value.	Value per Lb.	Lb.	Value.
1912..	884,204	$29,461	$0.033	3,393,354	$39,912	$0.012	7,332,392	$232,808
1913..	696,158	25,888	0.037	2,962,180	35,872	0.012	7,518,125	263,162
1914..	535,883	21,607	0.040	3,130,366	51,869	0.017	.....	.....
1915..	244,806	15,058	0.062	838,609	13,369	0.016	.....	.....
1916..	154,223	24,606	0.160	1,015,010	29,134	0.029	3,557,120	564,473
1917..	146,236	17,773	0.122	2,063,571	70,080	0.034	12,807,367	1,431,919
1918..	2,002	193	0.096	1,445	29	0.020	4,107,012	420,754
1919..	42,724	6,888	0.161	829,266	12,998	0.016	11,881,033	882,231
1920..	97,798	11,970	0.122	1,515,278	37,161	0.024	24,171,224	2,909,290
1921..	1,401,211	62,671	0.045	20,344,935	269,720	0.013	32,057,098	1,834,864

Year.	Sulphur.									
	Crude.				Flowers.			Refined.		
	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value
1912..	26,885	27,333	$494,778	$18.40	1,310	1,331	$39,126	1,665	1,692	$40,933
1913..	14,636	14,880	278,056	19.00	5,899	5,997	115,574	1,233	1,254	29,091
1914..	22,810	23,190	409,537	18.39	621	631	17,214	1,800	1,830	47,568
1915..	24,647	25,050	405,990	16.43	647	658	23,046	988	1,004	80,325
1916..	21,289	21,632	358,416	16.84	425	432	18,408	455	462	15,020
1917..	973	989	20,176	20.73	*Nil.*	.....	.....	37	38	9,164
1918..	55	56	1,602	30.76	*Nil.*	.....	.....	27	27	7,850
1919..	77	78	1,997	25.94	*Nil.*	.....	.....	24	24	6,636
1920..	44	45	1,722	39.14	*Nil.*	.....	.....	92	94	25,106
1921..	4	4	226	56.20	.....	.....	2	44	45	5,650

Year.	Talc.				Tin.			
	Short Tons.	Metric Tons.	Value.	Value per Sh. T.	Lb.	Metric Tons.	Value.	Value per Lb.
1912 ...	10,817	9,813	$121,541	$11.24	116,003,385	52,633	$50,371,102	$0.434
1913 ...	14,004	12,702	143,500	10.25	104,282,230	47,315	46,900,314	0.450
1914 ...	17,869	16,210	202,415	11.33	95,049,612	43,126	32,861,188	0.346
1915 ...	18,069	16,396	199,840	11.06	115,636,332	52,465	38,736,909	0.336
1916 ...	16,682	15,134	218,180	13.08	138,073,293	62,629	51,803,384	0.375
1917 ...	16,132	14,635	257,454	15.96	143,636,782	65,152	63,628,940	0.443
1918 ...	12,697	11,519	251,102	19.37	142,507,393	64,640	93,144,218	0.653
1919 ...	12,973	11,769	250,248	19.29	89,698,391	40,686	50,890,019	0.568
1920 ...	21,729	19,712	442,732	20.38	126,038,389	57,170	73,786,765	0.585
1921 ...	11,456	10,393	238,581	20.82	54,201,481	24,585	16,645,719	0.307

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Year.	Zinc.								
	Blocks, Pigs and Old.				Oxide. (*j*)		Sulphide.		Mfrs.
	Lb.	Metric Tons.	Value.	Value. per Lb.	Lb.	Value.	Lb.	Value.	Value.
1912	22,229,831	10,086	$1,280,426	$0.058	5,875,057	$386,153	5,904,475	$153,303	$293,089
1913	12,199,267	5,535	660,706	0.054	6,865,094	433,886	5,066,535	152,980	62,256
1914	1,759,579	798	71,165	0.040	5,258,108	302,838	9,072,567	277,862	31,724
1915	1,808,964	821	131,468	0.072	1,764,887	154,149	4,251,772	144,567	15,753
1916	1,368,560	621	119,000	0.087	930,267	185,395	63,419	8,862	1,205
1917	513,153	233	25,849	0.050	248,047	53,525	9,990	6,519	515
1918	70,552	32	4,953	0.071	330,201	63,746	2,670	993	426
1919	139,182	63	4,500	0.032	216,380	45,689	10,035	4,413	1,507
1920....	29,055	13	1,082	0.037	2,889,035	293,486	45,482	15,027	2,360
1921	13,478,548	6,114	571,543	0.042	2,687,235	162,620	93,537	8,330	548,211

(*a*) From Summary of Foreign Commerce of the United States. (*b*) Includes arsenic sulphide and white arsenic. (*c*) Barrels of 400 lb. (*d*) Exclusive of ground micas. (*e*) Not including iron ore. (*f*) Not reported. (*h*) Includes nickel oxide, alloys in which nickel is the principal constituent, and manufactures of nickel. (*i*) Containing more than 25 per cent. sulphur. (*j*) Includes white pigments containing zinc but not lead, dry and in oil. (*m*) Includes bars of steel and steel forms not elsewhere specified. The high value is due to the value of "high-speed" steel. (*p*) Matte, regulus, and metal. (*r*) Antimony contents of ore. (*s*) Not kainit. (*t*) Exclusive of pearls.

EXPORTS OF DOMESTIC PRODUCTS (*a*)

Year.	Aluminium and Mfrs. of.	Asbestos and Mfrs. of.	Cement.			
			Bbl.(*p*)	Metric Tons.	Value.	Value per Bbl.
1912	$1,347,621	$601,701	4,215,532	726,606	$6,160,341	$1.46
1913	966,094	754,102	2,964,358	510,949	4,270,666	1.44
1914	1,546,510	513,037	2,140,197	364,414	3,088,809	1.44
1915	3,682,117	764,050	2,565,031	437,466	3,361,451	1.31
1916	15,417,134	1,215,209	2,563,976	437,263	3,828,231	1.49
1917	14,586,467	2,049,131	2,586,215	441,078	5,329,588	2.06
1918	10,869,388	2,544,378	2,252,446	384,154	5,912,166	2.62
1919	3,890,326	3,689,394	2,463,573	420,162	7,513,389	3.05
1920	5,630,781	4,572,203	2,985,807	509,229	10,045,369	3.37
1921	3,108,857	2,708,042	1,181,024	201,424	4,277,135	3.62

Year	Coal.									
	Anthracite.				Bituminous. (*m*)				Coke.	
	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Value per L.T.	Long Tons.	Value.
1912	3,688,789	3,750,268	$19,425,263	$5.27	14,459,978	14,700,978	$36,817,633	$2.55	814,800	$3,002,742
1913	4,154,386	4,224,625	21,959,850	5.29	17,986,757	18,286,536	45,449,664	2.53	881,603	3,309,930
1914	3,830,244	3,894,081	20,211,072	5.28	13,801,850	14,031,881	34,104,903	2.47	592,487	2,233,686
1915	3,540,406	3,597,407	18,429,255	5.21	16,764,857	17,034,771	42,817,341	2.55	799,562	3,092,498
1916	4,165,652	4,232,719	22,470,147	5.39	18,977,346	19,282,881	45,828,092	2.41	1,048,790	4,202,236
1917	5,363,666	5,450,021	30,909,798	5.76	21,285,320	21,628,012	79,502,654	3.72	1,258,321	8,543,746
1918	4,435,543	4,506,955	29,215,689	6.59	19,956,009	20,277,301	78,664,856	3.94	1,506,986	11,861,408
1919	4,443,391	4,514,930	36,668,131	8.25	17,958,514	18,247,646	83,708,842	4.66	640,139	5,128,119
1920	4,824,776	4,902,455	45,538,100	9.44	34,390,254	34,943,937	304,273,241	8.86	821,252	9,993,669
1921	4,176,221	4,243,458	45,624,555	10.90	20,652,788	20,985,298	122,596,704	5.94	273,888	2,760,935

Year.	Copper.									
	Ore and Matte.				Ingots, Bars, Plates and Old.				Mfrs.	Total, Except Ore.
	Long Tons.	Metric Tons.	Value.	Value per L. T.	Lb.	Metric Tons.	Value.	Value per Lb.	Value.	
1912	66,171	67,274	$3,203,220	$48.41	775,000,658	351,634	123,007,884	$0.159	$3,762,283	$126,770,167
1913	65,684	66,779	2,973,997	45.28	926,241,092	420,255	143,353,624	0.155	1,555,493	144,909,117
1914	43,529	44,254	1,606,855	36.91	840,080,922	381,162	116,026,290	0.138	1,162,060	117,188,350
1915	57,731	58,660	453,125	7.85	681,917,955	309,311	117,250,816	0.172	7,885,472	125,136,278
1916	105,838	107,542	1,239,067	11.71	784,006,486	355,625	204,924,174	0.261	25,752,591	230,676,765
1917	67,721	68,811	1,615,960	23.86	1,126,875,368	511,139	337,107,796	0.300	16,957,876	354,065,672
1918	33,598	34,139	789,557	23.50	744,429,741	337,666	195,051,082	0.262	5,286,141	200,337,223
1919	3,003	3,051	128,541	42.80	515,959,108	234,034	117,288,514	0.227	4,557,812	121,846,326
1920	1,394	1,416	79,483	57.02	623,619,795	282,868	127,389,203	0.204	6,040,069	133,429,272
1921	1,355	1,377	38,705	28.56	628,446,688	285,057	85,308,223	0.136	3,971,701	89,279,924

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Year.	Gold.		Iron.							
			Ore.				Pig.			
	In Coin and Bullion. (c)	In Ore. (d)	Long Tons.	Metric Tons.	Value.	Value per L.T.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1912.....	$43,921,951	$470,333	1,195,742	1,215,671	$3,537,289	$2.96	272,676	277,221	$3,832,765	$13.84
1913.....	88,331,790	602,781	1,042,151	1,059,520	3,513,419	3.37	277,648	282,275	4,026,306	14.50
1914.....	220,409,005	285,038	551,618	560,812	1,794,193	3.20	114,423	116,330	1,638,102	14.32
1915.....	18,902,237	419,330	707,641	719,034	2,181,629	3.08	224,509	226,891	3,667,167	16.33
1916.....	155,484,759	308,168	1,183,952	1,203,014	3,692,496	3.12	607,236	617,012	15,381,431	25.33
1917.....	371,362,421	251,463	1,132,313	1,150,543	4,464,111	3.94	656,220	666,785	24,037,051	36.63
1918.....	40,157,762	532,692	1,256,383	1,276,611	5,535,090	4.41	269,575	273,915	11,576,721	42.98
1919.....	368,164,529	20,719	996,569	1,012,614	4,308,746	4.33	321,261	326,433	12,313,183	38.32
1920.....	320,700,663	11,260	1,145,037	1,163,472	6,198,927	5.41	216,828	220,319	10,074,377	46.46
1921.....	23,812,742	78,635	440,106	447,192	2,077,620	4.72	28,305	28,761	933,093	32.95

Year.	Iron, Bar.				Iron, Band, Hoop and Scroll.			Billets, Ingots and Blooms.			
	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value	Long Tons.	Metric Tons.	Value.	Value per L. T.
1912....	21,926	22,291	$841,824	$38.39	12,557	12,766	$539,354	294,818	299,732	$6,615,131	$22.44
1913....	16,615	16,892	768,501	46.25	16,841	17,122	767,631	91,847	93,378	2,200,248	23.96
1914....	5,226	5,313	203,835	39.00	9,954	10,120	457,451	50,496	51,338	1,103,702	21.86
1915....	39,726	40,375	1,471,466	37.04	29,250	29,721	1,433,879	560,704	569,721	14,176,528	25.28
1916....	74,069	75,258	3,913,849	52.83	43,208	43,904	3,251,882	1,504,562	1,528,785	90,095,601	59.87
1917....	56,332	57,239	5,046,727	89.60	58,768	59,711	7,330,301	2,017,113	2,049,589	161,391,007	79.98
1918....	63,367	64,384	6,576,362	103.78	50,673	51,486	7,711,195	1,786,189	1,814,937	150,568,151	84.30
1919....	60,547	61,522	5,634,398	93.06	50,836	51,654	6,875,586	258,424	262,585	19,370,787	74.96
1920....	46,627	47,377	4,651,224	99.75	53,449	54,310	6,445,155	216,873	220,365	12,645,950	58.31
1921....	12,340	12,539	1,190,669	96.49	20,280	20,607	2,017,511	10,363	10,530	518,517	50.04

Year.	Iron, Nails and Spikes, Cut.				Iron, Nails and Spikes, All Other.				Iron, Plates and Sheets.		
	Lb.	Metric Tons.	Value.	Value per Lb.	Lb.	Metric Tons.	Value.	Value per Lb.	Long Tons.	Met. Tons.	Value.
											$
1912	20,856,790	9,463	$359,962	$0.017	186,646,470	84,685	$3,976,571	$0.021	193,719	196,948	11,844,767
1913	8,488,503	3,851	165,068	0.019	132,014,432	59,898	3,031,967	0.023	98,978	100,628	6,568,413
1914	7,667,552	3,479	142,285	0.019	103,535,214	46,953	2,264,031	0.022	48,818	48,018	3,128,184
1915	9,487,774	4,304	190,667	0.020	255,562,644	115,923	6,048,240	0.024	101,449	103,082	6,603,002
1916	10,645,098	4,828	312,195	0.029	417,489,036	189,173	13,920,560	0.033	131,803	133,925	11,486,267
1917	10,136,192	4,598	434,766	0.043	348,214,785	157,947	17,965,560	0.051	148,723	151,097	20,748,607
1918	8,566,751	3,886	440,281	0.051	225,090,434	102,099	14,492,776	0.064	109,497	111,255	18,924,723
1919	6,542,341	2,967	393,284	0.060	292,956,260	132,877	18,278,862	0.062	141,532	143,811	20,061,836
1920	8,642,668	3,920	573,990	0.066	273,762,361	124,176	16,556,442	0.061	140,526	142,788	20,763,829
1921	2,451,171	1,112	133,629	0.055	91,760,682	41,622	5,258,873	0.057	68,406	69,507	9,324,835

Year.	Pipes and Fittings.			Steel, Sheets and Plates.			Steel Rails.			
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1912....	249,853	254,476	14,256,406	352,802	358,682	$14,508,622	446,473	453,914	$13,053,774	$29.24
1913....	301,790	306,649	17,999,990	364,448	370,522	4,472,711	460,553	468,229	13,979,549	30.35
1914....	199,621	202,835	11,020,557	232,078	235,946	9,308,312	174,680	177,591	5,103,918	29.22
1915....	176,933	179,779	10,210,439	318,154	323,276	11,764,484	391,379	397,680	12,095,170	30.90
1916....	228,573	232,253	16,183,989	383,755	389,933	23,046,571	540,328	549,535	20,417,582	37.76
1917....	204,719	208,015	24,142,769	683,015	693,980	84,543,248	512,669	520,923	24,023,090	39.94
1918....	145,943	148,293	21,659,554	715,380	726,864	90,325,377	453,537	460,839	26,402,864	58.25
1919....	275,535	279,971	40,407,502	887,479	901,767	77,916,180	652,443	662,953	38,986,855	59.74
1920....	353,188	358,874	53,527,742	1,000,845	1,016,958	94,195,241	594,628	604,202	36,193,689	60.86
1921...	393,889	400,231	56,218,936	529,301	537,823	42,017,742	322,107	327,293	18,460,790	57.31

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Year.	Structural Iron and Steel.				Wire.				Steel Wire Rods.			
	Long Tons.	Metric Tons.	Value.	Value per L.T.	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Value per L. T.
			$	$			$	$			$	
1912 .	288,164	292,967	12,694,804	44.05	244,711	248,790	11,536,442	47.14	64,978	66,061	1,898,986	29.22
1913 .	403,264	409,985	17,790,744	44.12	190,284	193,455	9,237,541	48.55	61,637	62,664	1,815,922	29.46
1914 .	182,395	185,435	6,961,636	38.17	180,842	183,856	8,568,589	47.38	61,856	62,887	1,810,389	29.27
1915 .	232,139	235,876	8,960,411	38.46	473,583	481,208	25,833,607	54.55	165,014	167,670	4,713,109	39.14
1916 .	300,594	305,434	17,541,862	58.48	683,025	694,028	52,224,940	76.46	158,284	160,832	8,109,111	51.23
1917 .	294,150	298,886	24,437,289	82.62	394,940	401,280	42,317,008	107.25	181,939	184,860	15,356,275	84.40
1918 .	232,729	236,476	21,468,452	92.24	392,301	398,599	44,197,043	112.66	148,522	150,906	12,469,715	83.96
1919 .	360,787	366,596	28,956,816	80.26	291,663	296,359	35,996,178	123.42	117,992	119,891	8,374,716	70.97
1920 .	493,633	501,580	38,384,690	77.76	320,679	325,842	41,427,122	129.20	116,770	118,650	8,884,854	76.09
1921 .	297,022	301,804	26,824,258	90.31	99,312	100,911	12,284,814	123.70	18,953	19,258	1,112,234	58.68

Year.	Lead and Mfrs. of.	Nickel. (*e*)	Petroleum products. (In Thousands of Units.)*								
			Crude.			Naphtha.			Illuminating Oil.		
			M Gals.	M Value.	Value per Gal.	M Gals.	M Value.	Value per Gal.	M Gals.	M Value.	Value per Gal.
1912...	$651,459	$8,515,332	188,711	$6,770	$0.036	186,000	$20,459	$0.110	1,026,138	$62,084	$0.061
1913...	738,135	9,686,794	194,570	8,448	0.043	188,043	28,092	0.149	1,119,441	72,042	0.064
1914...	5,519,908	9,455,528	124,736	4,959	0.040	209,693	25,288	0.121	1,010,449	64,113	0.063
1915...	11,758,979	10,128,514	158,263	4,283	0.027	281,609	33,885	0.120	836,959	49,989	0.059
1916...	17,095,451	12,952,493	172,028	7,030	0.041	355,870	68,661	0.192	854,688	55,863	0.065
1917...	18,243,661	8,936,620	172,121	7,668	0.045	415,879	93,134	0.224	658,156	48,954	0.074
1918...	15,318,910	6,927,041	205,829	12,084	0.059	559,369	139,593	0.250	491,110	50,354	0.102
1919...	8,106,371	1,697,544	248,821	14,806	0.060	372,134	92,050	0.247	979,155	119,024	0.122
1920...	6,535,050	574,845	337,886	28,990	0.086	641,310	175,540	0.274	870,665	133,290	0.153
1921...	3,814,272	103,372	372,351	20,204	0.054	533,090	130,907	0.246	748,959	93,898	0.125

Year.	Petroleum Products. (In Thousands of Units.)*									
	Lubricating Oil.			Fuel and Gas Oil. (*g*)			Paraffin.			
	M Gals.	M Value.	Value per Gal.	M Gals.	M Value.	Value per Gal.	M Lb.	M Metric Tons.	M Value.	Value per Lb.
1912 ...	216,393	$28,297	$0.131	266,237	6,599	$0.025	294,591	133.7	$9,603	$0.033
1913 ...	207,639	29,609	0.143	426,872	11,126	0.026	236,046	107.1	8,177	0.035
1914 ...	191,648	26,316	0.137	703,508	19,224	0.027	188,823	85.7	6,435	0.034
1915 ...	239,679	32,460	0.135	812,216	22,325	0.028	386,914	175.5	12,535	0.032
1916 ...	260,806	43,027	0.165	964,091	27,141	0.028	376,813	170.9	14,820	0.039
1917 ...	280,438	57,565	0.205	1,124,524	45,656	0.041	311,090	141.1	17,907	0.058
1918 ...	257,316	75,602	0.294	1,200,750	66,616	0.055	235,543	106.8	22,274	0.095
1919 ...	274,795	85,143	0.308	584,850	30,819	0.053	263,345	119.4	24,817	0.094
1920 ...	402.121	155,607	0.387	827,594	54,889	0.066	375,276	170.2	32,620	0.087
1921 ...	289,317	92,697	0.320	845,061	45,973	0.054	225,881	102.5	11,166	0.049

*** For convenience in tabulating, the quantities of all petroleum products and their gross values have been divided by 1000.**

Year.	Crude Phosphates.				Quicksilver.			Silver.	
	Long Tons.	Metric Tons.	Value.	Value per L.T.	Lb.	Metric Tons.	Value.	In Coin and Bullion (*c*)	In Ore (*d*)
1912....	1,206,520	1,226,629	$8,996,456	$7.46	23,283	11	$13,360	$66,846,486	$137,752
1913....	1,366,508	1,389,283	9,996,580	7.32	85,521	39	43,574	59,509,520	154,769
1914....	964,114	980,183	6,771,652	7.02	108,426	49	70,753	47,767,578	76,084
1915....	253,421	257,501	1,603,851	6.33	252,852	115	225,509	47,403,607	63,628
1916....	243,678	247,601	1,156,391	4.74	666,047	302	670,475	70,550,279	44,758
1917....	170,202	172,942	941,823	7.87	808,336	367	998,470	83,963,550	167,326
1918....	150,446	152,868	1,170,413	7.79	232,346	105	338,620	239,940,918	18,248
1919....	465,521	473,374	6,342,838	13.68	683,004	310	817,328	239,013,116	7,945
1920....	1,151,005	1,169,536	13,540,804	11.76	116,493	53	129,993	116,035,400	16,522
1921....	738,029	749,911	7,481,748	10.14	29,501	13	18,869	51,460,288	16,111

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Year.	Zinc Ore.				Zinc, Pigs, Bars, Plates and Sheet.			
	Long. Tons.	Metric Tons.	Value.	Value Per L.T.	Lb.	Metric Tons.	Value.	Value. per Lb.
1912.....	20,847	21,194	$823,997	$39.53	13,268,186	6,020	$864,292	$0.065
1913.....	15,815	16,079	631,991	40.00	15,565,324	7,062	955,667	0.061
1914.....	9,920	10,085	388,464	39.06	129,694,022	58,804	8,540,668	0.066
1915.....	743	755	35,276	47.48	251,348,910	114,008	31,556,838	0.125
1916.....	70	71	3,992	57.03	412,726,882	187,213	59,391,085	0.144
1917.....	1,179	1,198	63,043	53.47	436,947,774	198,195	50,765,389	0.118
1918.....	55	56	2,480	45.09	200,197,310	90,807	20,558,827	0.103
1919.....	*Nil*	.....	.....	.....	283,354,764	128,527	24,665,642	0.087
1920.....	*Nil*	.....	.....	.....	228,058,505	103,445	19,659,666	0.070
1921.....	*Nil*	.....	.....	.....	8,417,300	3,818	678,737	0.081

Year.	Zinc Oxide.			
	Lb.	Metric Tons.	Value.	Value per Lb.
1912.....	34,128,163	15 484	$1,247,702	$0.037
1913.....	28,932,953	13,127	1,136,257	0.039
1914.....	31,183,369	14,148	1,408,525	0.045
1915.....	39,978,569	18,134	2,068,428	0.052
1916.....	27,883,602	12,648	2,394,709	0.086
1917.....	30,891,886	14,012	3,148,898	0.102
1918.....	24,841,747	11,268	2,779,507	0.112
1919.....	29,405,334	13,340	3,059,276	0.104
1920.....	22,327,830	10,128	2,151,544	0.096
1921.....	5,021,509	2,278	426,253	0.092

RE-EXPORTS OF FOREIGN PRODUCTS (*a*)

Year.	Antimony.			Antimony Ore.			Asphaltum, Crude.		
	Lb.	Metric Tons.	Value.	Short Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1912.....	(*c*)50,684	23.0	$2,766	*Nil.*	*Nil.*	*Nil.*	2,589	2,632	$62,276
1913.....	63,620	29.0	4,365	0.18	0.16	$ 22	1,282	1,303	25,954
1914.....	1,600,979	725.7	211,742	*Nil.*	*Nil.*	*Nil.*	21	21	387
1915.....	3,146,135	1,427.0	786,766	.....	.....	8	237	241	4,706
1916.....	3,018,251	1,369.0	761,045	231	209	9,874	97	99	1,568
1917.....	989,477	449.0	169,260	*Nil.*	*Nil.*	*Nil.*	17	17	715
1918.....	1,410,970	640.0	164,666	*Nil.*	*Nil.*	*Nil.*	659	670	9,483
1919.....	429,059	194.1	33,913	3	3	1,665	257	261	7,858
1920.....	896,030	406.4	51,607	*Nil.*	*Nil.*	*Nil.*	1	1	46
1921.....	299,776	135.9	15,741	*Nil.*	*Nil.*	*Nil.*	54	55	3,808

Year.	Cement.			Chemicals.					
	Bbl.(*p*)	Metric Tons.	Value.	Salts of Potassium. (*f*)			Chloride of Lime.		
				Lb.	Kg.	Value.	Lb.	Kg.	Value.
1912...	4,586	791	$8,419	4,932,143	2,237,814	$103,425	400	181	$8
1913...	2,687	460	4,075	8,660,837	3,929,599	162,467	13,260	6,016	333
1914..	757	130	1,038	8,760,640	3,974,882	204,423	15,990	7,255	291
1915...	1,142	197	2,209	3,005,825	1,363,433	279,660	120,126	54,489	2,496
1916..	625	108	814	825,673	374,517	107,578	*Nil.*	*Nil.*	*Nil.*
1917...	*Nil.*	*Nil.*	*Nil.*	236,450	107,251	75,002	2,215	1,005	217
1918...	5	1	100	2,879	1,306	1,845	480	218	18
1919...	*Nil.*	*Nil.*	*Nil.*	2,099,968	952,524	165,116	495	224	52
1920...	*Nil.*	*Nil.*	*Nil.*	1,200,732	544,640	192,155	*Nil.*	*Nil.*	*Nil.*
1921...	848	145	3,478	1,236,730	560,967	72,297	63,801	28,940	1,914

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Year.	Chemicals. (Continued.)											
	Nitrate of Sodium.			Sodium Cyanide.			Soda Ash and Carbonate.			Sodium Salts, All Other.		
	Long Tons.	Metric Tons.	Value.	Lb.	Kg.	Value.	Lb.	Kg.	Value.	Lb.	Kg.	Value.
1912.	8,853	8,995	$440,200	.....	.....	.....	.....	.....	....	431,407	195,685	$9,416
1913.	5,560	5,653	295,111	.....	.....	.....	.....	.....	....	534,470	242,500	12,672
1914.	9,220	9,374	460,868	*Nil.*	*Nil.*	*Nil.*	.....	.....	....	.....	.....	13,662
1915.	22,743	23,109	1,123,761	1,897,727	860,790	347,079	.....	.....	....	.....	.....	40,358
1916.	53,453	54,314	3,432,273	222,916	101,112	58,625	.....	.....	....	.....	.....	193,086
1917.	69,779	70,902	5,367,281	276,801	125,554	115,067	.....	.....	....	.....	.....	25,632
1918.	54,706	55,591	5,204,413	125	57	148	.....	.....	....	.....	.....	73,402
1919.	13,673	13,893	1,299,563	*Nil.*	*Nil.*	*Nil.*	.....	.....	....	.....	.....	388,943
1920.	19,819	19,589	1,448,226	155,599	70,578	12,123	.....	.....	....	.....	.....	98,386
1921.	33,065	33,597	2,011,109	1,406,780	638,101	117,258	.....	.....	....	.....	.....	27,224

Year.	Coal, Bituminous.			Copper.						Graphite.	
				Ore and Matte.			Pigs, Bars, Ingots, Old, and All Unmanufactured.				
	Long. Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Lb.	Metric Tons.	Value.	Long Tons.	Value.
1912....	982	998	$6,574	*Nil.*	....	.....	1,020	0.5	$132	*Nil.*	.....
1913....	1,179	1,199	6,652	*Nil.*	....	.....	557	0.3	135	1	44
1914....	21,390	21,747	118,241	*Nil.*	....	.....	3,436	1.6	534	*Nil.*	.....
1915....	1,343	1,365	8,966	*Nil.*	*Nil.*	*Nil.*	801,872	364	151,369	.....	.....
1916....	24,257	24,648	77,001	2,739	2,783	55,675	7,629	3.4	1,529	.....	.....
1917....	5,150	5,233	33,336	5,898	5,993	118,213	61	.....	6	.....	.....
1918....	1,064	1,079	8,046	*Nil.*	*Nil.*	*Nil.*	1,400,630	635	357,535	.....	.....
1919....	2,082	2,117	12,597	*Nil.*	*Nil.*	*Nil.*	114,222	52	19,348	.....	.....
1920....	12,868	13,075	57,261	*Nil.*	*Nil.*	*Nil.*	3,346,106	1,518	604,461	.....	.....
1921....	2,346	2,390	24,178	*Nil.*	*Nil.*	*Nil.*	156,976	71	19,400	10	1,444

Year.	Iron and Steel.											
	Pig Iron.			Scrap.			Bar Iron.			Rails.		
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1912.....	5,087	5,169	$130.102	198	201	$3,788	25	25	$1,176	*Nil.*	....	.....
1913.....	765	778	29,257	70	71	771	68	69	6,099	49	50	$1,000
1914.....	218	222	14,105	186	189	2,136	13	13	1,007	*Nil.*	....	.....
1915.....	2,650	2,693	54,009	90	91	1,063	408	415	13,043	181	184	5,632
1916.....	961	976	63,555	244	248	4,667	24	24	2,137	19	19	503
1917.....	281	286	43,255	140	142	2,352	29	29	4,292	30	30	632
1918.....	1,443	1,466	286,165	*Nil.*	*Nil.*	*Nil.*	12	12	2,716	*Nil.*	*Nil.*	*Nil*
1919.....	*Nil.*	*Nil.*	*Nil.*	30	30	827	21	21	5,289	....	....	.....
1920.....	839	852	76,070	82	83	1,710	8	8	1,575	375	381	19,500
1921.....	159	162	19,641	7	7	217	21	21	3,386	4	4	254

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Year.	Iron and Steel. (*Continued.*)									Lead and Mfrs.
	Steel, Ingots, Blooms, Etc.			Sheets and Plates.			Tin and Terne Plates, Taggers Tin.			
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	
1912.....	470	478	$57,743	58	59	$6,786	175	178	$15,886	$2,704,062
1913.....	418	425	60,191	*Nil.*	.....	.....	1	1	250	2,107,796
1914.....	443	450	41,052	2	2	143	67	68	4,240	1,539,039
1915.....	153	155	27,262	88	89	6,112	139	141	9,018	1,082,948
1916.....	161	164	86,501	1	1	938	6	6	1,084	33,224
1917.....	88	89	41,653	234	238	49,190	.....	.....	25	255,299
1918.....	603	613	60,069	.....	.....	165	*Nil.*	*Nil.*	*Nil.*	708,742
1919.....	195	198	19,313	1	1	1,849	38	39	7,962	56,594
1920.....	212	215	92,809	13	13	2,716	9	9	2,250	119,105
1921.....	42	43	55,711	2	2	459	7	7	2,000	24,020

Year.	Salt.			Sulphur—Crude.			Tin in Blocks, Pig and Granulated.		
	Lb.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1912.....	73,551	33	$105	1,015	1,032	20,314	589	598	$591,726
1913.....	76,125,400	34,540	3,226	25	25	555	1,104	1,122	1,135,105
1914.....	5,196,300	2,357	14,349	309	314	7,074	802	815	647,017
1915.....	10,384,400	4,712	31,841	175	178	3,995	553	562	439,433
1916.....	14,897,300	6,757	61,525	104	106	2,187	140	142	129,006
1917.....	3,798,800	1,723	21,830	*Nil.*	*Nil.*	*Nil.*	79	80	84,070
1918.....	1,445,800	656	13,903	204	207	7,102	235	239	293,737
1919.....	913,300	414	7,992	60	61	1,478	68	69	92,230
1920.....	834,600	378	6,252	*Nil.*	*Nil.*	*Nil.*	297	302	378,604
1921.....	1,302,900	591	5,969	*Nil.*	*Nil.*	*Nil.*	358	364	260,960

(*a*) From Summary of Foreign Commerce of the United States. (*c*) Total exports of coin and bullion; that is, includes both foreign and domestic. (*d*) Only approximately correct. The Bureau of Statistics reports only the value of silver ores exported, but a much larger amount of silver leaves the country in copper matte, which is classified as copper ore, and no record is kept of its silver contents. The gold in copper matte exported is not included in the exports of gold given in the above table. These figures include ore of both domestic and foreign origin. (*e*) Includes nickel oxide and nickel matte. (*f*) Includes chlorate, chloride, nitrate, and all other salts of potassium. (*g*) Includes small amount of residuum, but does not include fuel oil for vessels engaged in foreign trade. (*m*) Does not include coal used for fuel on vessels for foreign trade. (*o*) Antimony contents of regulus, etc. (*p*) Barrel of 376 lb.

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